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Message from the General Chair

It is a great pleasure and honor for me to welcome you all to 9th Asian Control Conference – ASCC 2013.

ASCC 2013 is a major international conference series sponsored by Asian Control Association – ACA. It is technically co-sponsored by both IEEE Control System Society and IEEE Industrial Electronics Society. We believe that with its wide participation from many parts of the world, it will be a unique opportunity for automatic control researchers and engineers from academia and industries to exchange their research results and new findings.

The history of ASCC goes back to 1994 when the first ASCC was held in Tokyo. The subsequent conferences were then held in Seoul (1997), Shanghai (2000), Singapore (2002), Melbourne (2004), Bali (2006), Hong Kong (2009) and Kaohsiung (2011). It is for the time that it is being held at the edge of Asia, in Istanbul, in fact on its European part. The original hope was to hold European Control Conference; ECC and ASCC together but this it could not be achieved.

The technical program of ASCC 2013, is very rich, the topics of interest of cover a wide range, from classical to emerging ones. We have a number of special session organized, dedicated to various advanced areas. The richness of the program will certainly broaden our perspective of control and deepen our knowledge in the particular areas that we are interested in.

Istanbul is a unique city in the world. It was the capital of three great empires; Roman, Byzantine and Ottoman, and two religions; Christian and Islamic for more than 2000 years. It is therefore full of historic and cultural monumental buildings and masterpieces of Roman, Byzantine and Christian art. It is our hope that you will be able to spare some time to experience its cultural and historical riches.

A conference of this size cannot be brought together without the dedicated efforts of many people. I would like to take this opportunity to thank everybody involved in many committees. My special thanks go to the Technical Program Chair; Prof. Jinhu LU and his co-chairs; Profs. Xinghou YU and M. Onder EFE, and the members of the International Program Committee. The graduate students in my laboratory, such as Yeşim Öniz and Çisel Aras deserve my very special thanks because without their involvement, I would not have been able to face the challenges of my responsibilities.

Finally I would like to wish you all a very pleasant stay in Turkey and a safe return home. I hope that the international atmosphere at ASCC 2013 will inspire new friendships among engineers and scientists of the world and we will see each other in Malaysia for the next edition of ASCC.

Okyay Kaynak
General Chair
WELCOME FROM THE ACA PRESIDENT

It gives me great pleasure to welcome you all to Asian Control Conference (ASCC) 2013 held in Istanbul, Turkey, the flagship conference of Asian Control Association (ACA) held once every two years. As President of ACA, I sincerely hope all the participants will enjoy the technical conference program as well as the cultural visit to such long-standing but colorful city during June 23~26.

ACA is a great organization dedicated to promoting various activities on control science and engineering technology in Asia Pacific. So far, it has also served as a platform for control societies and individuals in such continent to collaborate or to exchange information in various control aspects. Looking into the future, members of ACA may come all over from East Asia (Japan, Korea, China, Taiwan, etc.), South East Asia (Singapore, Thailand, Malaysia, Indonesia, Vietnam, Philippines, etc.), South Asia (India, Pakistan, etc.), West Asia (Turkey, Iran, Iraq, etc.), and Oceana (Australia, New Zealand, etc.). With giant coverage of potential members in the globe, ACA strategically collaborate with a number of local societies and institutions in order to provide even better services to members from more countries and regions belonging to this part of the world.

ASCC 2013 is the 9th Asian Control Conference, and the past conferences were respectively held in Tokyo (1997), Shanghai (2000), Singapore (2002), Melbourne (2004), Bali (2006), Hong Kong (2009), and Kaohsiung (2011). On behalf of ACA, I would like to send the special thanks and congratulations to General Chair, Prof. Okyay Kaynak, and Program Chair, Prof. Jinhu Lu, of this conference and their entire organization team who have made tremendous efforts to organize such conference and have successfully attracted over 700 paper submissions from all over the world, which is truly a record submission in the history of ASCC after only full paper submissions were accepted dated back in 2004. This great achievement have already coined a sound success of the conference because it gathers a large quantity of world control experts and scholars in the conference venue for four consecutive days to exchange their knowledge and to create giant momentum to move forward in control discipline. Therefore, I am sure you will definitely benefit from participating in this conference, ASCC 2013.

Last but not the least, I wish you a stimulating, rewarding, and enjoyable conference.

Li-Chen Fu
President of ACA, 2013
MESSAGE FROM THE TECHNICAL PROGRAM CHAIRS

It is our great pleasure to welcome you to the 9th Asian Control Conference (ASCC 2013) in Istanbul, Turkey, a unique city on two continents in the world, which was the capital of three great empires, Roman, Byzantine and Ottoman, and two religions, Christian and Islamic, for more than 2,000 years.

ASCC 2013 has received overwhelming responses from researchers around the globe with 711 submissions from 56 countries for regular submissions (one of the largest ASCC in its history), from which 447 papers were accepted. This corresponds to an acceptance rate of 62.87%. The exciting technical program is designed to create a platform for researchers and engineers to showcase their latest research findings, exchange ideas and network with fellow researchers. The technical program is composed of 68 Lecture Sessions and 2 Poster Sessions, as well as 12 Invited Sessions covering emerging and interdisciplinary topics ranging from some representative fields of Systems and Control. Furthermore, the program consists of keynote speeches by some of renown experts in Systems and Control. Lei Guo from Chinese Academy of Sciences will discuss the synchronization in flocks with large population. Tamer Basar from University of Illinois at Urbana-Champaign, USA will share his vision on the future of multi-agent networked systems with adversarial elements. Iven Mareels from The University of Melbourne, Australia will look into the future of four millennia of irrigation water management via a systems engineer's perspective. We hope the rich technical content provides wonderful opportunities for all participants from academia and industries to network with colleagues and to exchange latest findings in Systems and Control field.

We are very grateful to the Technical Program Committee members for organizing the reviews and paper selections in the final program. A total of 1,537 reviews from all over the world were received, which gives an average of 2.16 independent reviews for each paper. We wish to express our sincere appreciation to 75 Associate Editors and 812 reviewers for their devoted efforts, and of course to all the authors for their efforts in preparing their papers. The smooth review process is not possible without the strongest support of Jifeng Zhang, the Chair of Technical Committee on Control Theory (TCCT) of Chinese Association of Automation (CAA), and Hongsheng Qi, the Vice-General Secretary of TCCT of CAA, who provided valuable support to the web-based review system.

Finally, we would like to specially express our gratitude to the Invited Session Chairs, Zhongping Jiang, Zongli Lin, Huijun Gao, and Veysel Gazi, who put considerable effort into coordinating all invited session papers. We also thank the Award Chairs, Changyun Wen, Daniel W. C. Ho, and Zhisheng Duan, for organizing the evaluating processes for Shimemura Young Author Prize, Best Paper Prize, and Best Application Paper Prize, and also the Tutorials/Workshop Co-Chairs, Levent Guvenc, Peng Shi, and Haitao Zhang, for putting together a wonderful set of tutorial and tutorials with exciting topics and speakers.
We hope each and every one of you enjoys the technical program and Istanbul. We also hope you find time to feel the spirit of “Turkey Culture” besides the technical program and appreciate the Cappadocia and Ephesus, and many other historical sites during your stay in Istanbul.

Jinhu Lu, Onder Efe, and Xinghuo Yu
Technical Program Chairs
Advisory Committee
Li-Chen Fu (Chairman), National Taiwan Univ.
David Banjerdpongchai, Chulalongkorn Univ.
Xiren Cao, Shanghai Jiao Tong University, China
Seul Jung, Chungnam National University, Korea
Maizuki Khalid, Universiti Teknologi Malaysia
Hidenori Kimura, Univ. Tokyo, Japan
Wook Hyun Kwon, Seoul National Univ., Korea
Iven Mareels, Univ. Melbourne, Australia
Mitsuji Sampei, Tokyo Inst. Technol., Japan
Kai Tai Song, National Chiao Tung Univ., Taiwan
Kenko Uchida, Waseda University, Japan
Sangchul Won, Pohang Univ. Sci. Technol., Korea
Yugeng Xi, Shanghai Jiao Tong University, China
Ji-Feng Zhang, Chin. Acad. Sci.

General Chair
Okyay Kaynak, Bogazici Univ., Turkey,

Program Chairs
Onder Efe, Univ. of Turkish Aeronautical Assoc., Turkey
Xinghuo Yu, RMIT Univ.

Publication Chairs
Cisel Aras, Bogazici University, Turkey
Guanrong Chen, City Univ. Hong Kong
Erdal Kayacan, Katholieke Univ. Leuven, Belgium

Invited Session Chairs
Zhongping Jiang, Polytech. Inst. NYU, USA
Zongli Lin, Univ. Virginia, USA
Huijun Gao, Harbin Inst. of Tech., China
Veysel Gazi, Kemerburgaz University, Turkey

Award Chairs
Changyun Wen, NTU, Singapore
Daniel W. C. Ho, City Univ. Hong Kong
Zhisheng Duan, Peking University, China

Local Arrangement Chair
Okyay Kaynak, Bogazici Univ., Turkey,

Publicity Chairs
Tzuu-Hseng S. Li, National Cheng Kung Univ.
Renquan Lu, Hangzhou Dianzi Univ., China
Changyin Sun, Southeast University, China

Finance Chairs
Aynur Özmen, Bogazici Univ. Foundation, Turkey

Registration Chairs
Hairong Dong, Beijing Jiaotong Univ., China
Yesim Oniz, Bogazici University, Turkey

Tutorials/Workshop Co-Chairs
Levent Guvenc, Okan University, Turkey
Peng Shi, University of Glamorgan, UK
Haitao Zhang, Huazhong Univ. Sci. Technol

Industrial Forum and Exhibits Chair
Shuzi Sam Ge, NUS, Singapore
Wenwu Yu, Southeast University, China

Web Master
Cisel Aras, Bogazici University, Turkey,

International Program Committee

Members
Hanxiong Li, City Univ. Hong Kong
Gang Feng, City Univ. Hong Kong
Shuichi Adachi, Utsunomiya Univ., Japan
Sunil Kumar Agrawal, Univ. of Delaware
Bijnan Bandyodhayay, IIT Bombay, India
Giorgio Battistelli, Università degli Studi di Firenze
Zhongping Jiang, Polytech. Inst. NYU, USA
Zhenwei Cai, Swinburne Univ, Australia
Jinde Cao, Southeast Univ., China
Che Wai Chan, Univ. of Hong Kong
Fan-Ren Chang, National Taiwan Univ.
Chang-Po Chao, National Chiao Tung Univ.
Ben M. Chen, National Univ. of Singapore
Hung-Chi Chen, National Chiao Tung Univ.
I-Ming Chen, Nanyang Technol. Univ., Singapore
Jian-Shiang Chen, National Tsing Hua Univ.
Xiang Chen, Univ. of Windsor, Canada
Zhiyong Chen, Univ. of Newcastle, Australia
Min-Sen Chiu, National Univ. Singapore,
Jyh-Horng Chou, NKFUST
Chung Choo Chung, Hanyang Univ.
Steven Ding, Duisburg Univ.
Guangren Duan, Harbin Inst. Technol., China
Meng Joo Er, Nanyang Technol. Univ.
Shumin Fei, Southeast Univ., China

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Yong Feng, RMIT Univ., Australia
I-Kong Fong, National Taiwan Univ.
Hisaya Fujioka, Kyoto Univ., Japan
Minyue Fu, Univ. Newcastle, Australia
Eric H K Fung, Hong Kong Polytech. Univ.
Huijun Gao, Harbin Inst. Technol., China
Dongbing Gu, Univ. of Essex, UK
Zhihong Guan, Huazhong Univ. Sci. Tech., China
Abraham H. Haddad, Northwestern Univ.
Qinglong Han, CQ Univ., Australia
Hideki Hashimoto, Univ. Tokyo, Japan
Keum-Shik Hong, Pusan Univ.
Yiguang Hong, Chin. Acad. Sci.
Zhongsheng Hou, Beijing Jiaotong Univ., China
Pau-Lo Hsu, National Chiao Tung Univ.
Han-Pang Huang, National Taiwan Univ.
Chia-Feng Juang, National Chung Hsing Univ.
Jyh-Ching Juang, National Cheng Kung Univ.
Jayantha Katupitiya, The Univ. of New South Wales
SuIyang Khoo, Deakin Univ., Australia
Akira Kojima, Tokyo Metropolitan Univ., Japan
Jozef Korbicz, Univ. of Zielona Gora
Yasuaki Kuroe, Kyoto Inst. Technol., Japan
James Lam, Univ. Hong Kong
Weiyao Lan, Xiamen Univ., China
Ti-Chung Lee, Minghsin Univ. Sci. Technol.
Shihua Li, Southeast Univ., China
Tzuu-Hseng S. Li, National Cheng-Kung Univ.
Feng-Li Lian, National Taiwan Univ.
Kuang-Yow Lian, National Taipei Univ. of Technology
Der-Cherng Liaw, National Chiao Tung Univ.
Chih-Min Lin, Yuan Ze Univ.
Chun-Liang Lin, National Chung Hsing Univ.
Zongli Lin, Univ. of Virginia, USA
Guo-Ping Liu, Univ. of Glamorgan, UK
Jie Huang, Chin. Univ. Hong Kong
Jun Wang, Chin. Univ. Hong Kong
Kang-Zhi Liu, Chiba Univ.
Tzong-Shi Liu, National Chiao Tung Univ.
Wanquan Liu, Curtin Univ. Technol., Australia
Zhihong Man, Swinburne Univ., Australia
Hari Muhammad, Institut Teknologi Bandung
Yul Yunazwin Nazaruddin, Institut Teknologi Bandung
Yoshito Ohta, Kyoto Univ.
Toshiyuki Ohtsuka, Osaka Univ.
Yasuaki Oishi, Nanzan Univ.
Koichi Osuka, Osaka Univ.
Ju H Park, Yeungnam Univ.
Beibei Ren, National Univ. of Singapore
Hyungbo Shim, Seoul National Univ.
Chunyi Su, Concordia Univ., Canada
PLENARY SPEAKERS

Monday, 9:20-10:20AM, June 24, 2013
Room: 30 Agustos Zafer
Title: Synchronization in Flocks with Large Population
Chair: Jinhu Lu

Speaker: Professor Lei Guo (Academy of Mathematics and Systems Science, Chinese Academy of Sciences, China)

Abstract
A fundamental issue in complex systems theory is to understand how locally interacting agents (or particles) leads to global behaviors (or structures) of the systems. Such problems arise naturally from diverse fields ranging from material and life sciences to social and engineering systems, and have attracted much research attention in recent years. In this lecture, we will focus on the synchronization problems of two basic classes of non-equilibrium multi-agent systems (or flocks) described respectively by the geometric distance and the topological distance. By working in a stochastic framework and by overcoming the widely recognized theoretical difficulty—establishing some kind of dynamical connectivity needed for guaranteeing synchronization of the flocks, we are able to provide a rigorous and fairly complete theory for synchronization of flocks with large population. The main theorems are established based on analyses of the nonlinear dynamical equations involved and of the asymptotical properties of the spectrum of random geometric graphs. Furthermore, we will show how the global behaviors of the flocks may be intervened by using the “soft control” idea, without changing the existing interaction rules of the agents.

Biography
Professor Lei Guo received his B.S. degree in mathematics from Shandong University in 1982, and Ph.D. degree in control theory from the Chinese Academy of Sciences (CAS) in 1987. He was a postdoctoral fellow at the Australian National University (1987-1989). Since 1992, he has been a Professor of the Institute of Systems Science at CAS. He has been the President of the Academy of Mathematics and Systems Science, CAS (2003-2012), and is currently the Director of the National Center for Mathematics and Interdisciplinary Sciences, CAS.

Dr. Guo was elected Fellow of the IEEE in 1998, Member of the Chinese Academy of Sciences in 2001, Fellow of the Academy of Sciences for the Developing World (TWAS) in 2002, Foreign Member of the Royal Swedish Academy of Engineering Sciences in 2007, and Fellow of the International Federation of Automatic
Control (IFAC) in 2007 “for fundamental contributions to the theory of adaptive control and estimation of stochastic systems, and to the understanding of the maximum capability of feedback”. He was also the recipient of the 1993 IFAC World Congress Young Author Prize “for solving a long standing problem in control theory concerning convergence and convergence rate for the least-squares–based self-tuning regulators”. He was a plenary speaker at the IFAC World Congress in 1999, an Invited speaker at the International Congress of Mathematicians (ICM) in 2002, and currently an IEEE CSS Distinguished Lecturer (2012-), among others.

He has served as a Council Member of IFAC (2005-2011), Associate Editor of SIAM J. Control and Optimization (1991-1993) and Systems and Control Letters (2003-2010), General Co-Chair of the 48th IEEE Conference on Decision and Control (2009), and Vice-President of the Chinese Mathematical Society. Currently, he serves as the President of the China Society for Industrial and Applied Mathematics (CSIAM), the Congress Director of the 8th International Congress on Industrial and Applied Mathematics (ICIAM’2015), a Vice-President of the Chinese Association of Automation, and a member of editorial boards of a number of academic journals in mathematics, systems and control.

He has worked on problems in stochastic systems including adaptive control, system identification, and adaptive signal processing. His current research interests include the maximum capability of feedback, multi-agent systems, game-based control systems, filtering and control of nonlinear systems, and quantum control systems, among others.
Abstract
The recent emergence of multi-agent networks has brought about several non-traditional and non-standard requirements on strategic decision-making, thus challenging the governing assumptions of traditional control and game theory. Some of these requirements stem from factors such as: (i) limitations on memory, (ii) limitations on computation and communication capabilities, (iii) heterogeneity of decision makers (machines versus humans), (iv) heterogeneity and sporadic failure of channels that connect the information sources (sensors) to decision units (strategic agents), (v) both temporal and spatial limitations on the exchanges between different decision units and the actions taken by the agents, (vi) operation being conducted in a hostile environment where some of the disturbances are controlled by adversarial agents, (vii) lack of cooperation among multiple decision units, and (viii) lack of a common objective shared by multiple control stations. These all lead to substantial degradation in performance and loss in efficiency unless appropriate mechanisms are put in place. The talk will identify the underlying challenges, particularly those that are brought about by the adversarial nature of the environment. One specific problem that will be addressed is distributed averaging and consensus formation in the presence of an adversary with limited actions. Another problem that will be discussed is that of connectivity maintenance in vehicular networks in the presence of mobile jammers, where the problem is formulated as a multiplayer pursuit-evasion game. The talk will conclude with a discussion of some other selected problems in this general area.

Biography
Professor Tamer Basar was born in Istanbul, Turkey. He received the B.S.E.E. degree from Robert College in 1969, and the M.S., M.Phil, and Ph.D. degrees in engineering and applied science from Yale University in 1970, 1971 and 1972, respectively. After holding positions at Harvard University and Marmara Research Institute, he joined the University of Illinois at Urbana-Champaign (UIUC) in 1981, where he currently holds the academic positions of Swanlund Endowed Chair, Center for Advanced Study Professor of Electrical and Computer Engineering, Professor at the Coordinated Science Laboratory, Professor at the Information Trust Institute, and Affiliate Professor at the Department of Mechanical Science and Engineering. He spent sabbatical years at Twente University of Technology (the Netherlands; 1978-79), and INRIA (France; 1987-88, 1994-95).

Dr. Basar has published extensively in systems, control, communications, and dynamic games, including 4 books, 4 edited volumes, over 230 journal articles and book chapters, and over 350 conference publications. He is currently the Editor-in-Chief of Automatica, the Editor of the Birkhäuser Series on Systems
& Control, the Editor of the Birkhäuser Series on Static & Dynamic Game Theory: Foundations and Applications, the Managing Editor of the Annals of the International Society of Dynamic Games (ISDG), an Editor of Springer Briefs: Control, Automations and Robotics, and member of editorial and advisory boards of several international journals in control, games, networks, and applied mathematics. His current research interests include stochastic teams and games; routing, pricing, and congestion control in communication networks; control over wired and wireless networks; sensor networks; formation in adversarial environments; mobile and distributed computing; risk-sensitive estimation and control; mean-field game theory; game-theoretic approaches to security in computer networks, including intrusion detection and response; and cyber-physical systems.

Tamer Basar has received several awards and recognitions over the years, among which are the Medal of Science of Turkey (1993); Distinguished Member Award (1993), Axelby Outstanding Paper Award (1995), and Bode Lecture Prize (2004) of the IEEE Control Systems Society (CSS); Tau Beta Pi Drucker Eminent Faculty Award of UIUC (2004); Quazza Medal (2005) and Outstanding Service Award (2005) of the International Federation of Automatic Control (IFAC); Bellman Control Heritage Award (2006) of the American Automatic Control Council (AACC); honorary doctorates (Doctor Honoris Causa) from Dogus University (Istanbul; 2007), National Academy of Sciences of Azerbaijan (2011), and Bogazici University (Istanbul; 2012); honorary professorship from Northeastern University (Shenyang; 2008); and Isaacs Award of ISDG (2010). He is a member of the US National Academy of Engineering, a member of the European Academy of Sciences, a Fellow of IEEE, a Fellow of SIAM, a Fellow of IFAC, and a current elected member of IFAC Council. He was the president of IEEE CSS (2000), the founding president of ISDG (1990-1994), and the president of AACC (2010-2011).
Abstract

One of the great world challenges is to double the world's food production over the next 40 years. A goal the world must realise without using significantly more water, land or fertiliser: a food productivity revolution of a magnitude never realised before in human history.

It is our thesis that systems engineering principles can (and should) play a major role in addressing this food security challenge.

In this lecture, we briefly introduce the present food security challenge and in particular focus on the water productivity aspects.

Next we review the history of irrigation, starting in the fertile crescent where the first urban civilisations settled backed by irrigation based agriculture. It is here, as early as 1800BC, that the Sumerians recorded the water management practices that first underpinned, but later destroyed, their society. Since then the irrigated land area has increased 400-fold, and the world population has grown by a factor of 200.

The "irrigation management" problem of delivering water, using gravity as the driving force, through a (large scale) irrigation channel network to meet farmer requirements may be captured as a receding horizon predictive control problem. A decentralised approximate solution which scales well is presented. This solution has been implemented in a large scale irrigation renewal project in Australia comprising about 6,000km of main canal, over 18,000 in-channel regulating structures, and about 20,000 onto farm outlets. This district typically allocates 3,000 Gl per annum. Results from this implementation will be presented.

Presently research and development is shifting from the channel automation to the smaller scale of on-farm automation and the larger scale of river automation. On farm the goal is to increase (economic) water productivity. On the river scale we want to meet environmental objectives.
We conclude with describing some of the important remaining challenges in addressing water resource management on its geographically relevant scale: an entire water catchment area.

Biography

Professor Iven Mareels is the Dean of the School of Engineering, the University of Melbourne, a position he took on in June 2007. He obtained the (ir) Masters of Electromechanical Engineering from Gent University Belgium in 1982 and the PhD in Systems Engineering from the Australian National University, Canberra, Australia in 1987.

Prior to commencing as a Professor of Electrical Engineering at the University of Melbourne in 1996, he held appointments at the Australian National University (1990-1996), the University of Newcastle (1988-1990) and the University of Gent (1986-1988), as well as various visiting appointments at the University of Twente, The Netherlands; National University of Singapore; University of California, both at Santa Barbara and San Diego; and Valencia University of Technology, Valencia, Spain. He is honorary Professor at Zhejiang University, China; National University of Defence Science and Technology, China; and Shanghai Jiao Tong University, China.

He has received several awards in recognition of his research and teaching. He was a recipient of a 2008 Clunies Ross Award, Academy of Technological Sciences and Engineering for his work on Smart Irrigation Systems. In 2007 he received the inaugural Vice-Chancellor’s Knowledge Transfer Excellence award from the University of Melbourne, for his work in large scale irrigation systems with Rubicon Systems Australia. In 2005, he was named IEEE CSS Distinguished Lecturer, and in 1994 received the Vice-Chancellor’s Award for Excellence in Teaching from the Australian National University.

He is Fellow of the Academy of Technological Sciences and Engineering, Australia, a Fellow of the Institute of Electrical and Electronics Engineers (USA), a member of the Society for Industrial and Applied Mathematics, a Fellow of the Institute of Engineers Australia. He is a Member of the Royal Flemish Belgian Academy of Sciences and Humanities. He is registered as a Corporate Professional Engineer and he is a member of the Engineering Executives chapter of Engineers Australia. He is a founding member of the Asian Control Association, and a member of the organising committee for the Mathematical Theory in Networks and Systems conference. Over the period Jan 2003-Dec 2005 he was a member of the Board of Governors of the Control Systems Society IEEE. He was the Chair of the National Committee for Automation, Control and Instrumentation (Australia 2005-2009). He is the Chair of the Technical Board of the International Federation of Automatic Control (and ex-officio Vice-President) for 2008-2014. He is a member of the Steering Committee of the Mathematical Theory in Networks and Systems group.

He is a Member of the Board of the Bionic Ear Institute (since 1998), a Member of the Board of SPIRE (since 2002), a Member of the Board of Bionic Vision Australia (since 2009) and a Member of the Scientific Advisory Committee for the Melbourne Neuropsychiatry Centre (since 2009) and a Member of the Steering Committee for the Centre for Neural Engineering (since 2009) as well as a Member of the Steering Committee for the Melbourne based IBM Research Centre, an a member of the Advisory Boards for The Institute for Broadband Enabled Society and the Melbourne Materials Institute.

He has extensive experience in consulting for both industry and government. He has strong interests in education and has taught a broad range of subjects in both mechanical and electrical engineering curricula. He was one of the main developers (1990-1996) of the Bachelor of Engineering at the Australian National University and one of the architects (2006-...) of the 3+2 Master of Engineering education at Melbourne.
His research interests are in adaptive and learning systems, nonlinear control and modelling. At present his research focuses on modelling and controlling of large scale systems, both engineered as well as natural systems, such as large scale water networks, smart grids and epilepsy.

Iven Mareels has published 5 books, in excess of 120 journal publications and 230 conference publications. He holds a suite of 23 international patents in the field of irrigation system management. He has supervised to completion more than 30 PhD students, 10 MPhil students and is currently supervising 3 PhD students and 2 MPhil students.
The rich technical program of ASCC 2013 is complemented by one workshop and four tutorials that will take place on Sunday, June 23, 2013. The workshop and tutorials will take place in the Engineering Building, Vedat Yerlici Conference Center in Bogaziçi University campus, one of the top universities in Turkey, with a beautiful view of the Bosporus. We will start with a workshop on using "LEGO Mindstorms with MATLAB and Simulink for Teaching Controls, Robotics and Mechatronics" that will be presented by the Mathworks from 11:00 to 14:00. After a lunch break, four workshops will take place in parallel from 15:00 to 18:00. The conference welcome reception will take place in the roof terrace of the same building at 18:30-21:30. Transportation from the city hotels to the workshop/tutorial site and back to the hotels after the conference welcome reception will be provided by the conference organization. Detailed information on the workshop and the tutorial sessions is listed below. Please register early for these exciting events as space is limited.

Sunday, June 23, 2013, 11:00-14:00

Workshop W1: LEGO® MINDSTORMS® NXT with MATLAB and Simulink for Teaching Controls, Robotics and Mechatronics
Presenter: Dr. Mischa Kim, Mathworks Germany

This workshop describes the built-in support for prototyping, testing, and running Simulink models on LEGO® MINDSTORMS® NXT. This platform aims to address the growing need for hands-on and project-based learning via a low-cost, easy to use hardware and software platform that builds on the widely used MATLAB & Simulink platform. The Simulink built-in support for hardware enables students to access the hardware capabilities of the 32-bit LEGO NXT brick from within Simulink environment, and to automatically generate and cross-compile the necessary code for real time autonomous implementation. Faculty who attend will have a chance to work through lab modules with examples of embedded genetic algorithms, motor speed control and mobile inverted pendulum. They will have an opportunity to gain practical hands-on experience in building such high-level examples themselves, and by extension understand the potential for use in the classroom with undergraduate students.

Sunday, June 23, 2013, 15:00-18:00

Tutorial T1: On-line Optimization: Extremum Seeking Control and its Applications
Presenters: Prof. Iven Mareels, Assoc. Prof. Chris Manzie and Dr. Ying Tan

Extremum seeking control (ESC) is a real time optimization method for steady-state optimization of engineered systems. It is an enabling technology that is used in a range of important applications, such as power generation, irrigation, optical communication, environmental monitoring and economics. The main objective of this tutorial is to present the fundamentals of extremum seeking control to systems and control researchers who may not be familiar with the concept. This tutorial will describe several streams of ESC from around the world and will provide participants with an overview of the current state-of-the-art in ESC from the basic ESC theory through to current design practice, example applications, and ongoing research directions.

Tutorial T2: Developing Cyber-Physical Systems: Autonomous Vehicles in Regular Traffic
Presenters: Prof. Ümit Özgüner, Prof. Keith Redmill, Dr. Arda Kurt
In this tutorial we will cover aspects of the analysis and synthesis of Cyber-Physical Systems (CPS), concentrating on the design of Autonomous Vehicles. We shall specifically consider autonomous and semi-autonomous cars in a street network, interacting with human-driven cars. Topics that will be covered are: Modeling of interconnected dynamic systems, Information and coordination hierarchies, Hybrid system modeling, Autonomous vehicles. Examples will be from the Urban Challenge, an intersection approach, 4 communicating cars, testing large CPS.

**Tutorial T3: Control of Mechatronic Systems Using the COMES Toolbox**  
**Presenters:** Prof. Levent Güvenç, Prof. Bilin Aksun Güvenç, Mümin Tolga Emirler

This tutorial concentrates on four different approaches that are widely used in controlling mechatronic systems. These control approaches are: classical control, preview control, disturbance observer control and repetitive control. The COncontrol of MEchatronic Systems (COMES) toolbox developed as a Matlab based graphical user interface for designing classical, preview, disturbance observer and repetitive controllers will be introduced and used in the examples. The focus of the tutorial will be more on the disturbance observer and repetitive control methods. For these two approaches, the method of mapping frequency domain criteria like sensitivity minimization, phase/gain margin bounds to controller parameter space will be presented as an easy to use, interactive and practical method of designing low order controllers. This method allows the use of frequency domain specifications in a parameter space design setting. Three case studies will be used to illustrate the presented methods. The first case study is on yaw stability control of a road vehicle based on the disturbance observer. The second case study is on control of the piezo-tube in an atomic force microscope using a disturbance observer. The third case study is on repetitive control applied to an atomic force microscope.
GENERAL INFORMATION

Conference Venue

ALL Sessions of ASCC2013 are held at Military Museum, Istanbul. The workshop, tutorials and welcome cocktail will take place in the Engineering Building, Vedat Yerlici Conference Center in Bogaziçi University, South Campus.

How to reach Bogazici University?

The best way is to take a taxi, from Harbiye region, it should cost no more than 20 TL.

Location

Cultural Center of Askeri Muze (Military Museum) is located at Harbiye, nearby Taksim, center of modern Istanbul.

Address

Askeri Muze (Military Museum), Cumhuriyet Cd, Harbiye, İstanbul, Turkey.

Language

The native language in Turkey is Turkish, but the language of this conference will be English. Simultaneous translation will not be provided.

Currency

The Turkish monetary unit is “Turkish Lira”. The exchange rates can be learned at the information desk of the hotel or at exchange offices nearby.
REGULAR SESSIONS
A Study on the Spectrum of Monodromy Operator for A Time-Delay System

Jung Hoon Kim¹, Tomomichi Hagiwara¹, Kentaro Hirata²

¹Kyoto University, Japan; ²Nara Institute of Science and Technology, Japan

This paper studies the spectral properties of monodromy operators, which play an important role in stability analysis of linear time-invariant time-delay feedback systems. The paper is motivated by the fact that this operator can actually be defined naturally on four spaces, where the difference stems from different choices for the function space on which the infinite-dimensional state of such a time-delay system is assumed to take its value. It is first shown that the spectrum of the monodromy operator is independent of the spaces on which it is defined. It is further shown that the operator spectrum is continuous at monodromy operators, which is a crucial fundamental fact in justifying the spectrum computation of the monodromy operator through its approximation by any sort of tractable operators.

On Near-Controllability of A Class of Three-Dimensional Discrete-Time Bilinear Systems

Lin Tie, Yan Lin

Beijing University of Aeronautics and Astronautics, China

This paper studies near-controllability of a class of three-dimensional discrete-time bilinear systems. A necessary and sufficient criterion for the systems to be nearly controllable is obtained by using the root locus theory. Furthermore, the control inputs that achieve the state transition for the nearly controllable systems can be computed. An example is provided to demonstrate the results of the paper.

H-Infinity Performance Analysis with Transients for Singular Systems

Zhiguang Feng¹, James Lam², Shengyuan Xu², Shaosheng Zhou³

¹The University of Hong Kong, Hong Kong; ²Nanjing University of Science and Technology, China; ³Hangzhou dianzi University, China

In this paper, the problem of a generalized type of H-infinity performance analysis is investigated for continuous-time singular systems, which treats a mixed attenuation of exogenous inputs and initial conditions. First, a performance measure that is essentially the worst-case norm of the regulated outputs over all exogenous inputs and initial conditions is introduced. Necessary and sufficient conditions are obtained to ensure the singular system to be admissible and the performance measure to be less than a prescribed scalar. Moreover, the relationship between the performance measure and the standard H-infinity norm of the system is provided. A numerical example is given to demonstrate the properties of the obtained results.

All Solutions and Pole Assignments for the Regular Triangular Decoupling Problem

Dongmei Shen, Musheng Wei

Shanghai Normal University, China

In this paper, all explicit solutions of the regular triangular decoupling problem are derived by applying the canonical decomposition of the right invertible system \$\{C, A, B\}\$ obtained in Wei, Cheng and Wang (2010). Based on the formulas, all attainable transfer function matrices for the decoupling and pole assignment problem are characterized.

On the Computation of Mixing Coefficients Between Discrete-Valued Random Variables

Mehmet Eren Ahsen, Mathukumalli Vidyasagar

University of Texas at Dallas, United States of America

Mixing coefficients between two random variables act as a measure of their dependence. For stochastic processes mixing is another way of saying that the process is asymptotically independent. To measure mixing different types of mixing coefficients are introduced. In the literature, three kinds of mixing coefficients are commonly used, namely alpha-, beta- and phi-mixing coefficients. While it is easy to derive an explicit closed-form formula for the $\beta$-mixing coefficient, no such formulas exist for the $\alpha$- and the $\phi$-mixing coefficients. We study the case where the two random variables assume values in a finite set. Under this setup, we show that the computation of alpha-mixing coefficient is NP-hard. Moreover, by using a semi-definite relaxation we obtain lower and upper bounds for the alpha-mixing coefficient. We also derive a closed form expression for the phi-mixing coefficient between two random variables. These results generalize earlier results by the authors.
A Riesz Basis Approach to Exponential Stability in Thermoelasticity of Type III
Jing Wang, Jun-Min Wang
Beijing Institute of Technology, China
Using a Riesz basis approach, we investigate, in this paper, the exponential stability for a one-dimensional linear thermoelasticity of type III with Dirichlet-Dirichlet boundary conditions. A detailed spectral analysis gives that the spectrum of the system contains two parts: the point and continuous spectrum. It is shown that, by asymptotic analysis, there are three classes of eigenvalues: one is along the negative real axis approaching to $-\infty$, the second is approaching to a vertical line which parallels to the imaginary axis, and the third class is distributed around the continuous spectrum which is an accumulation point of the last classes of eigenvalues. Moreover, it is pointed out that there is a sequence of generalized eigenfunctions, which forms a Riesz basis for the energy state space. Finally, the spectrum-determined growth condition holds true and the exponential stability of the system is then established.

24th June, Monday
10:40-12:40 at Malazgirt 1
MoA2 Aerospace (I)
Session Chair : Zengqiang Chen, Nankai University, China
Session Co-Chair: Vangelis Petratos, University of Patras, Greece

Sliding Mode Controller Design for Spacecraft with Manipulator Systems
Sung-Mo Kang, Yun-Tae Kim, Hyo-Sung Ahn
Gwangju Institute of Science and Technology, South Korea
In this paper, we consider a sliding mode controller for the spacecraft which has a manipulator. The developed controller controls the pose of spacecraft and the position of end-effector. It is assumed that the joint value, the position of end-effector and the pose of spacecraft can be measured, but there are uncertainties in the kinematic and dynamic parameters. The controller also estimates uncertain parameters. With the help of Lyapunov stability analysis, we show that the proposed control approach ensures stability. Simulation results are included to illustrate the theoretical results.

Graphical Description of Autopilot Robustness to Aerodynamic Uncertainties
Mingwei Sun 1, Shengzhui Du 2, Zengqiang Chen 1
1Nankai University, China; 2University of South Africa, South Africa
In practice, flight control engineers conventionally check the robustness of a control system by perturbing several vital aerodynamic derivatives in addition to the calculation of stability margin. In this paper, an explicit geometrical approach is developed for the stability robustness analysis with structured aerodynamic uncertainties. A few parameters are considered as primary concerns according to empirical knowledge to reduce calculation complexity. A robust polygon is plotted for these vital parameters without any conservativeness. Moreover a computationally efficient method for calculating the largest stable hypercube in the parameter space is proposed in a straightforward manner, which eliminates the difficulties that arise in obtaining the corresponding $\mu$ singular value subject to real parameter uncertainties. Two examples are provided to illustrate the effectiveness of the proposed method. The familiar experience popularly used in practice can be explained in nature by the proposed method.

Estimation of Debris Hazard Areas due to a Space Vehicle Breakup at High Altitudes
Mahmut Reyhanoglu 1, Juan Alvarado 2, Avishy Carmi 2
1Embry-Riddle Aeronautical University, USA; 2Nanyang Technological University, Singapore
With the recent developments in the Commercial Space Transportation industry, there has been a surge of interest in the analyses of the debris hazard areas due to a space vehicle breakup and the risk posed to the aircraft in the national airspace system as well as to the people and the property on the ground. The focus of this paper is to study the problem of estimation of the extent of the airspace containing falling debris due to a space vehicle breakup. A precise computation of propagation of debris to the ground is not practical for many reasons. There is insufficient knowledge of the initial state vector; ambient wind conditions; and key parameters, including the ballistic coefficient distributions. In addition, propagation of all debris pieces to the ground would require extensive computer time. In this paper, a computationally efficient covariance propagation method is employed for the estimation of debris dispersion.

Bezier Approximation Based Inverse Dynamic Guidance for Entry Glide Trajectory
Tawfiqur Rahman, Hao Zhou, Wanchun Chen
Beihang University, China
An explicit entry guidance law has been developed using inverse dynamics approach. The inverse dynamics problem is solved through Bézier curve approximation of the vehicle trajectory. Most important and novel feature of the developed guidance law is its ability to satisfy the terminal angular and velocity constraints besides position constraints. Through shape preserving ‘Bézier parameters’ the guidance law has the ability to control terminal velocity. For entry glide flight the guidance law incorporates limits on acceleration and attack angle which are converted from path constraints. The results demonstrate remarkably good efficiency in meeting terminal constraints.
Adaptive Robust Fault-Tolerant Attitude Control of Spacecraft with Finite-Time Convergence
Qi Qiang Shen, Danwei Wang, Senqiang Zhu, Eng Kee Poh, Tianqi Liu
Nanyang Technological University, Singapore

This paper aims at investigating finite-time fault-tolerant attitude stabilization control designs for rigid spacecrafts involving two types of actuator faults and modeling uncertainties. In order to express the attitude dynamics in a more convenient manner, the Lagrange-like equation is adopted to describe spacecraft attitude dynamics. Using the terminal sliding mode technique, an on-line adaptive law is employed to estimate the bounds of the uncertainties, and finite-time convergence is achieved by an adaptive fault-tolerant controller in spite of actuator faults. Besides showing fault-tolerant capability, finite-time stability is also guaranteed not only in the reaching phase but also in the sliding phase. Simulation results illustrate the effectiveness of the proposed method.

Control of the Relative Movement of Hydraulically Driven Linear Moving Parts
Jarissa Maselene, Robin De Keyser
1Katholieke Universiteit Leuven, Belgium; 2Ghent University, Belgium

In this paper a control strategy is designed to control the relative movement of two linear moving parts on a real-life application driven by a hydraulic circuit. The hydraulic circuit has two motors in series configuration, each bypassed by a direct current controlled cartridge valve. On the output side, the speed of the linear moving parts and the time at which they reach a fixed endposition is measured. First, identification of the valves is done on an experimental basis. Second, these models are validated and a controller for the phase difference between the two linear moving parts is designed. The controller consists of a combination of PI and PID controllers for both speed and position synchronization.

Stabilization of Multi-Agent Systems via Distributed Difference Feedback Control
Yuping Tian, Di Xin, Ouyi Tian
1Southeast University, China; 2The Hong Kong University of Science and Technology, Hong Kong

Difference feedback control (DFC) uses the difference between the current state (output) and some delayed state (output) to compensate the feedback loop of the system. It does not alternate the original equilibrium of the system and thus can be used for stabilization of systems with unknown steady states. In this paper we extend the idea of DFC to network-based multiagent systems with sufficiently large input or communication delays. An explicit design scheme is provided for choosing the parameters of distributed difference feedback controller (DDFC). By taking the self-delays of DDFC as some commensurate values of input delays of the multi-agent systems, it is shown that the first-order integer system with any large diverse input delays and communication delays can be stabilized by DDFC. The result is applied to the synchronization of a network of Kuramoto oscillators with diverse input delays.

Controllability and Stabilizability of Higher-Order Nonholonomic Systems
Jaime Rubio Hervas, Mahmut Reyhanoglu
Embry-Riddle Aeronautical University, USA

This paper studies the nonlinear modeling and control problem for systems with higher-order nonholonomic constraints using tools from differential geometry. A number of control-theoretic properties such as nonintegrability, controllability, and stabilizability are first derived. The applicability of the theoretical development is illustrated through a third-order nonholonomic system example: a planar PPR robot manipulator subject to a jerk constraint. In particular, it is shown that although the system is not asymptotically stabilizable to a given equilibrium configuration using a time-invariant continuous feedback, it is strongly accessible and small-time locally controllable at any equilibrium.

Synthesis Method of Gene Regulatory Networks Having Desired Expression-Pattern Transition Sequences
Yoshihiro Mori, Yasuaki Kuroe
Kyoto Institute of Technology, Japan

Recently, synthesis of gene regulatory networks having desired behaviors has become of interest to many researchers and several studies have been done. We proposed a synthesis method of gene regulatory networks, in which desired behaviors are given by expression pattern sequences. Expression pattern sequences describe approximate behavior of gene regulatory networks. There are information being not used for synthesis. In this paper, we propose a synthesis method of gene regulatory networks, in which desired behaviors are given by expression pattern sequences and transition times of the expression pattern. We formulate the synthesis problem as an optimization problem. We solve the optimization problem by
A Step Forward to Pinning Control of Complex Networks: Finding An Optimal Vertex to Control

Wenwu Yu1, Jinhu Lu2, Xinghuo Yu3, Guanrong Chen4
1Southeast University, China; 2Chinese Academy of Sciences, China; 3RMIT University, Australia; 4City University of Hong Kong, Hong Kong

Synchronization in complex networks has been widely investigated recently. However, if a network cannot reach synchrony by itself, pinning control needs to be applied on a small fraction of vertices in the network. In the last decade, many pinning schemes were designed for choosing appropriate pinning vertices. However, the challenging problem as which vertices should be controlled to achieve the best performance for synchronization still has no solution. This paper focuses on the first step toward this challenging open problem. By using spectral analysis and algebraic graph theory tools to separate the network, it is found that an optimal vertex for pinning a network to achieve the best performance in synchronization must be in the matched pinning component or the matched cut vertex set.

Sampling Rate Tracking Control of Networked Control Systems Based on Cognitive Knowledge of Packet Disordering

Jinna Li1, Li-Feng Wei1, Daqing Zhang1, Chao Liu2, Haibin Yu1, Qingling Zhang4
1Shenyang Institute of Automation, Chinese Academy of Sciences, China; 2Shenyang Institution of Chemistry and Technology, China; 3University of Science and Technology Liaoning, China; 4Northeastern University, China

This paper focuses on the sampling rate tracking control of networked control systems (NCSs) with packet disordering. In view of the coupled relation between packet disordering and sampling rate, a novel sampling rate control algorithm, referring to the cognitive knowledge of packet disordering, is presented. Based on it, a controller that jointly controls sampling rate and the plant is proposed, and an augmented model of NCSs is constructed. A sufficient condition under which the whole systems are stochastically stable is derived. Moreover, the actual sampling period tracks a desired sampling period according to the tracking control method. The controller design is presented for NCSs in terms of linear matrix inequalities (LMIs) technique. Finally, a numerical example is given to illustrate the effectiveness of the proposed method.

Modeling of Guide Disk Speed of Rotary Piercer Based on PCA-ELM

Dong Xiao1, Jichun Wang2, Zhizhong Mao3, Shaohua Shi3
1Northeast University, China; 2Liaoning University of Technology, China; 3Institute of Automation, China

Piercer is an important equipment in seamless steel tubes production. The guide disc model is proposed by the analysis to hydraulic system which drives guide disc which is important for its control. Load-torque which is the important parameter in model is predicted by soft measure method. A PCA-ELM soft sensor model is proposed to estimate the guide disc speed in rolling piercing process successfully. The accuracy system is proved by simulation.

Coordinated Control of A Four-Area Power System under Structural Perturbation

Xuebo Chen, Chen Ma
Liaoning University of Science and Technology, China

This paper discusses the procedure of coordinated controller design under system structural perturbation when new interconnections are adding into the overall system. With the concept of pair-wise decomposition, a group of adding matrices is defined to obtain the structure-changed transformation matrices used in permuted inclusion principle. By adjusting the former controller’s structure corresponding to the information structure constraints variation, the new coordinated controller is capable of achieving high performance after this structural perturbation. A numerical simulation of automatic generation control (AGC) for a four-area power system under information structure constraints addition is provided by coordinated control.

Distributed State Estimation for Lur’e Systems in Sensor Networks with Impulsive Effects and Intermittent Measurements

Xiaomei Zhang1, Lei Yan1, Yufan Zheng2
1Nantong University, China; 2Shanghai University, China

This paper is concerned with the problem of distributed state estimation for Lur’e systems in sensor networks with impulsive effects and intermittent measurements. Based on a Lyapunov function method, sufficient conditions are presented which ensure all node estimators converging asymptotically. The gains of the estimators are obtained by solving certain linear matrix inequalities with some algebra constraints. Numerical examples are given to illustrate the effectiveness of the proposed estimation method.
High-Order Consensus in High-Order Multi-Agent Systems
Yuping Tian, Ya Zhang
Southeast University, China

This paper studies the high-order consensus problem for high-order multi-agent systems with heterogeneous dynamics and diverse communication delays. A necessary and sufficient condition is given for the existence of high-order consensus solution to heterogeneous multi-agent systems. The obtained condition shows that for systems with diverse communication delays, high-order consensus does not require each self-delay of agent is equal to the corresponding communication delay. A matching condition for self-delays and communication delays is derived.

Evolutionary Game Dynamics of Multi-agent Cooperation Driven by Self-Learning
Jinming Du, Bin Wu, Long Wang
Peking University, China

Multi-agent cooperation problem is a fundamental issue in the coordination control field. Individuals achieve a common task through association with others or division of labor. Evolutionary game dynamics offers a basic framework to investigate how agents self-adaptively switch their strategies in accordance with various targets, and also the evolution of their behaviors. In this paper, we analytically study the strategy evolution in a multiple player game model driven by self-learning. Self-learning dynamics is of importance for agent strategy updating yet seldom analytically addressed before. It is based on self-evaluation, which applies to distributed control. We focus on the abundance of different strategies (behaviors of agents) and their oscillation (frequency of behavior switching). We arrive at the condition under which a strategy is more abundant over the other under weak selection limit. Such condition holds for any finite population size of $N \geq 3$, thus it fits for the systems with finite agents, which has notable advantage over that of pairwise comparison process. At certain states of evolutionary stable state, there exists “ping-pong effect” with stable frequency, which is not affected by aspirations. Our results indicate that self-learning dynamics of multi-player games has special characters. Compared with pairwise comparison dynamics and Moran process, it shows different effect on strategy evolution, such as promoting cooperation in collective risk games with large threshold.

The Influence of Degree Mixing Patterns on Synchronization Paths
Mingyang Zhou$^1$, Shimin Cai$^2$, Zhao Zhuo$^1$, Zhong-Qian Fu$^1$
$^1$University of Science and Technology of China, China; $^2$University of Electronic Science and Technology of China, China

Many real networks display assortative and disassortative degree mixing patterns. In this paper, the impact of assortativity on the ubiquitous synchronizing process is systematically investigated. A rewiring model is adopted to generate networks of various assortativity following the same degree distribution. Numeric simulations of phase synchronization are carried in synthetic assortative networks. By carefully observing the collective dynamics in synchronizing processes, we find that assortative networks are more likely to reach local synchronization than disassortative ones even if they obey identity degree distributions. Moreover, the synchronizing process in assortative and disassortative SF networks show different synchronizing patterns, which are indicated by the merging of equivalent small synchronized clusters and growing of one large synchronized core. In the meanwhile, the assortative pattern affects synchronizing process stronger than disassortative pattern when they deviate from neutral network at the same assortativity degree. Phase synchronizing processes are also carried in assortative and disassortative random networks and results show that degree mixing has little influence, which suggests that the influences of assortativity in SF networks might be attributed to the strong heterogeneous of power-law degree distribution.

Stability Analysis of Social Foraging Swarm with General Nonlinear Attraction and Repulsion Forces and Interaction Time Delays
Weiyun Pan, Yufan Zheng
Shanghai University, China

In this paper we consider a class of social foraging swarms with nutrient/toxic profiles and general nonlinear attraction and repulsion structure, as well as interaction with constant time-delay. The paper considers the condition, which extends some existent results. The emergent behavior of the swarm motion is the result of a balance between inter-individuals interactions and the simultaneous interactions of the swarm with their environment. We show that the agents of social foraging swarm with interaction time-delay will asymptotically form a cohesive cluster with finite size for different profiles under some assumptions and we estimate the size of the bounded area. We give several numerical simulations demonstrating the validation of our results. Simulations also show that the swarm may display some complex dynamics behavior depending on different coupling matrices and time delays.
Stochastic Stability Conditions for A Class of Neutral Markovian Jump Systems
Xinghua Liu, Hongsheng Xi
University of Science and Technology of China, China

The certain and uncertain neutral systems with timevarying delay and Markovian jump parameters are investigated in this paper. The jumping parameters are considered as a continuous-time, continuous state Markov process. Based on the Lyapunov functional approach, novel delay-dependent stochastic stability criteria are presented in terms of LMIs. Two numerical examples are given to illustrate the effectiveness of the developed method.

Quantized State Feedback Stabilization with Signal-to-Noise Ratio Constraints
Yu Feng¹, Xiang Chen², Guoxiang Gu³
¹Zhejiang University of Technology, China; ²University of Windsor, Canada; ³Louisiana State University, USA

This paper deals with the problem of state feed-back stabilization for single-input discrete-time systems over a communication channel, where both logarithmic quantization error and white noise are included. The logarithmic quantizer is characterized by a received signal-to-error ratio (R-SER) model and the white noise is modelled by additive white Gaussian noise (AWGN) channel where a signal-to-noise constraint is imposed. The desired control law is aimed to stabilize the system in the presence of quantized error and to satisfy some pre-specified power constraint, simultaneously. A solvability condition is derived in terms of Mahler measure of the plant and the desired feedback controller is obtained through solving an algebraic Riccati equation. An example is included to illustrate the current results.

A Spline-Based Technique for Optimal Set Point Regulation through Pseudo-Inversion of Nonminimum Phase Linear Systems
Valentina Orsini, Raffaele Romagnoli, Leopoldo Jetto
Polytechnical University of Marche, Italy

This paper considers the optimal output set-point regulation for MIMO, non minimum phase sampled data systems. The usually proposed methods are based on stable model inversion whose exact solution is approximated through preview based implementation schemes. The new approach proposed here considers the meaningful practical situation of plants with a given, possibly uncertain, initial state, that can not be modified through pre-actuation. The structure of the optimal control input is “a priori” assumed to be given by a smoothing spline function. In this way a twofold objective is achieved: a smooth behavior of the control input and its derivatives can be imposed, a very accurate tracking performance can be obtained by reducing the mesh size of spline [cite{DeBoor}]. Given the desired transient output response between two fixed set points, the spline coefficients are determined as the least-squares solution of the over determined system of linear equations obtained imposing that the spline function assumed as control input yield the specified output. In this way an optimal least square approximation of the desired output trajectory is obtained avoiding the explicit stable model inversion. Rather, this operation is implicitly approximately performed solving for the spline coefficients, the over-determined system of linear equations carrying the information on the model to be inverted and on the desired output. An interesting feature of this new method is that it also works for linear systems which are not required to be either square or right invertible.

Solution to Second-order Nonhomogeneous Generalized Sylvester Equations
Guang-Ren Duan
Harbin Institute of Technology, China

In this paper, a new type of nonhomogeneous second-order generalized Sylvester equations (GSEs) are proposed. A complete general parametric solution in a neat explicit closed form is established using the F-coprimeness condition. The primary feature of this solution is that the matrix \( F \) does not need to be in any canonical form, or may be even unknown a priori. The matrix \( R \), together with the matrix \( F \); may be both set undetermined and used as degrees of freedom beyond the completely free parameter matrix \( Z \): The results provide great convenience to the computation and analysis of the solutions to this class of equations, and can perform important functions in many control systems analysis and design problems involving second-order dynamical systems.

On A Type of Second-Order Generalized Sylvester Equations
Guang-Ren Duan
Harbin Institute of Technology, China

In this paper, a new type of second-order generalized Sylvester equations (GSEs) associated with the general eigenstructure assignment of a type of second-order linear systems are proposed. Degrees of freedom is first investigated using the concept of F-coprimeness, and a complete general parametric solution in a neat explicit closed form is then established using a generalized matrix fraction right factorization. The primary feature of this solution is that the matrix \( F \) does not need to be in any canonical form, or may be even unknown a priori. The results provide great convenience to the computation and analysis of the solutions to this class of equations, and can perform important functions in many control systems analysis and design problems involving second-order dynamical systems.
A New Method Based on the Polytopic Linear Differential Inclusion for the Nonlinear Filter
Bing Liu, Zhen Chen, Xiangdong Liu, Fan Yang, Jie Geng
Beijing Institute of Technology, China

This paper describes a new nonlinear filter for the nonlinear system, motivated by the deficiencies of the complexity and large calculation number in the general nonlinear filter. The new filter is performed in three stages: First, the predicted state quantities of the nonlinear system are obtained by the prediction equation of the EKF. Then, the estimation error system is represented via an uncertain polytopic linear model, on the bias of which, the rectification equations with constant coefficients for the predicted errors are designed, without the need to evaluate the Jacobian matrices on line. Finally, the state estimates are given through updating the predictions by the rectified quantities. The main novelty of the paper is the application of the Polytopic Linear Differential Inclusion in the nonlinear system, leading to the simplified design of the nonlinear filter and the improved real time performance of the new filter than the EKF, though the accuracy is a little decline. Its effectiveness is demonstrated by using the statistics result of the calculation number for the filters and an example of application in the attitude estimation system.

The Active Disturbance Rejection Control for Nonlinear Systems Using Time-Varying-Gain
Bao-Zhu Guo1, Zhiliang Zhao2, Cui-Zhen Yao3
1Academy of Mathematics and System Sciences, Academia Sinica, China; 2University of Science and Technology of China, China; 3Beijing Institute of Technology, China

The active disturbance rejection control, as a new control strategy in dealing with the large uncertainties, has been developed rapidly in the last two decades. Basically, the active disturbance rejection control is composed of three main parts: the differential tracking; the extended state observer; and the extended observer-based feedback control. In these three parts, the extended state observer plays a crucial role toward the active disturbance rejection control. The most of the extended state observers are based on the constant high gain parameter tuning which results inherently in the peaking problem near the initial time, and at most the attenuation effect for the uncertainty. In this paper, a time-varying-gain extended state observer is proposed for a class of nonlinear systems, which is shown to reject completely the disturbance and to avoid effectively the peaking phenomena by the proper choice of the gain function. The convergence for the extended state observer for the open-loop system is independently proved. The convergence for the closed-loop system which is based on the extended state observer feedback is also presented. Examples and numerical simulations are illustrated the convergence and the peaking diminution.

Tracking Control for Piezo-Actuated Stage using Sliding Mode Controller with Observer-based Hysteresis Compensation
Taufiq Muhammadi1, Wookyong Kwon1, Duckman Lee2, Sangchul Won1
1Pohang University of Science and Technology, South Korea; 2Pohang Iron and Steel Co., South Korea

This paper presents a tracking control scheme for positioning of piezo-actuated stage under hysteresis effect. The hysteresis is estimated by an nonlinear observer and is compensated via feedforward control. Sliding mode controller is employed as a feedback control to track the reference. Experimental results showed effectiveness of the proposed scheme.

Input-to-State Stability for Switched Nonlinear Time-Delay Systems
Wang Yue-E1, Xi-Ming Sun1, Wei Wang2, Jun Zhao3, Zili Zhan4
1Northeastern University, China; 2Dalian University of Technology, China; 3Dalian Seasky Automation Co., China

This paper investigates the problem of the input-to-state stability (ISS) for a class of switched nonlinear time-delay systems, in which time delays are involved in both the state and the switching signal of the controller. Because of the presence of the switching delay, the switching information available to the controller is a delayed information of the system, and then the closed-loop system will have two asynchronous switching signals. To study these two asynchronous switching signals in a unified framework, we adopt the technique of the merging switching signal. Based on a piecewise Lyapunov-Krasovskii functional method, some sufficient conditions are explicitly given to guarantee ISS of the switched nonlinear time-delay system under average dwell time scheme.

Passivity-Based Observer Design and Robust Output Feedback Control for Nonlinear Uncertain Systems
Wei Liu1, Zhiming Wang2, Guoliang Chen3, Laihua Sheng4
1East China Normal University, China; 2Del Mar College, USA

This paper presents a new method for a passivity-based observer design and robust output feedback control of nonlinear uncertain systems. The uncertainties satisfy the Lipschitz-type condition. Firstly, the passivity condition, which assures the existence of an observer, is expressed in terms of a linear matrix inequality (LMI). Then, for the output feedback control, a sufficient condition in terms of LMI is given for input-to-state stability (ISS) with regard to the observer error. Meanwhile,
the observer error decays to zero. Therefore, the asymptotic stability is guaranteed by ISS. It is shown that the proposed method is much less conservative. Finally, a simulation example is illustrated the effectiveness of the proposed results.

Model-based Fault Detection and Diagnosis Optimization for Process Control Rig
Ribhan Zafira Abdul Rah1, Rubiyah Yusof2, Fatimah Sham Ismail2
1Universiti Putra Malaysia, Malaysia; 2Universiti Teknologi Malaysia, Malaysia

One of the challenges research on model based fault detection and diagnosis of a system is finding the accurate models. In this paper, fuzzy logic based model using genetic algorithm for optimizing the membership function is used in the development of fault detection and diagnosis of a process control rig. The model is used to generate various residual signals, which relate to the faults of the system. These residual signals are used by artificial neural networks to classify the respective faults and finally to determine the faults of the system. Comparisons of the fault classification technique are done for two different models of the process control rig that are the conventional fuzzy model and the optimized fuzzy-GA model. The results show that the fuzzy-GA model gives more accurate fault classifications as compared to the conventional fuzzy logic model.

24th June, Monday
10:40-12:40 at 30 Agustos Zafer
MoA7 PID Control
Session Chair: Jianda Han, Shenyang Institute of Automation, China
Session Co-Chair: Masami Saeki, Hiroshima University, Japan

Model Free Analysis and Tuning of PID Controller
Zhiquiang Zhu, Kun Liu, Yuqing He, Juntong Qi, Jianda Han
Shenyang Institute of Automation, China

In this paper, a new PID parameter tuning method is proposed. First, extensive analysis of the PID frequency properties is conducted. Based on the analysis results, the concept of characteristic frequency of the PID controller is proposed, which builds a relationship between the PID parameters and the oscillation characteristics of the closed loop response of the PID control system. Second, extensive study is made on how the PID parameters influence the closed loop system response characteristics. Third, based on the characteristic frequency of the PID controller and the corresponding analysis results, a set of tuning rules of the PID parameters are proposed, which are based on the characteristics of the closed loop response. The merits of these tuning rules are: only the characteristics of the closed loop response of the control system are required in the tuning process, while the system model of the controlled object is not required. Finally, the effectiveness of these tuning rules is verified by the simulation results on several typical models of the controlled objects.

Tracking Performance and Disturbance Rejection of Pneumatic Actuator System
Syed Najib Syed Salim1, Mohd Fuaad Rahmat2, Ahmad Athif Mohd Faudzi3, Zool Ismail4, Noorhazirah Sunar5, Sharatul Izah Samsudin1
1Universiti Teknikal Malaysia Melaka, Malaysia; 2Universiti Teknologi Malaysia, Malaysia

This paper investigates several control strategies that potential to perform well in regulating and tracking set point of pneumatic actuator system and able to reject disturbance. The system consists of 5-port proportional valve with dead-band flow and double rod cylinders that exhibit significant friction. Two control strategies of PID and NPID controllers with four different configurations with and without dead-zone compensators (DZC) are simulated. Three different input signals including step, sinusoidal and random waveforms are used to evaluate the performance of the proposed techniques. The effectiveness of NPID+DZC has been successfully demonstrated and proved through simulation and experimental studies.

Rendering of Unfalsified PID Gain Sets for Parameter Space Control Design
Masami Saeki
Hiroshima University, Japan

In this paper, a new approach to the data-driven PID control design in parameter space is proposed. A set of PID gains that are falsified by a necessary condition for the maximum sensitivity constraint is visualized by volume rendering. Because of the recent development of parallel computation and GPU(graphics processing units), volume rendering can be easily applied, and our main concern is how fast the volume data can be calculated. We give an estimation method of the l2 gain using a filter bank from a finite length response data, and this method is used for the volume data calculation at ten-thousand grid points. Efficiency and accuracy of our algorithm are examined by numerical experiments.

Dominant Three Pole Placement in PID Control Loop with Delay
Pavel Zitek, Jaromir Fiser, Tomas Vyhlidal
Czech Technical University in Prague, Czech Republic

In applying the pole assignment to tuning the PID controllers the usual presence of delay in the control loop brings about an infinite order character of the system dynamics, i.e. an infinite spectrum of poles. Therefore any pole placement can result in the desired tuning of the control loop only if the prescribed and placed poles really become the dominant poles of the
control loop dynamics. With respect to three parameters of PID controller just three poles can be placed by the assignment and a dominance guarantee of their prescription is crucial in this way of tuning. A novel method of selecting a trio of numbers with an equal real part to make them the dominant poles of the control loop is dealt with in the paper with an additional minimizing the absolute error integral. An original assessment is introduced to check the dominance of the pole placement and an optimum of relative damping of the response is assessed to minimize the control error integral. The quality of the disturbance rejection response is taken as the decisive criterion in the presented design of the time delay plant control.

A Method for Performance Improvement of PID Control by Dual-Input Describing Function (DIDF) Method
YeonWook Choe
Pukyong National University, South Korea

Though various techniques have been studied as a way of adjusting parameters of PID controllers, no perfect method of determining parameters is available to date. This paper proposes a new method for enhancing performance of PID controllers by using the characteristics of dual-input describing function (DIDF). In other words, if nonlinear elements with two inputs (DIDF) are connected in series to the plant, the critical point (-1+j0) for Nyquist stability theory can be moved to a position arbitrarily selected on the complex plane by determining necessary coefficients of the DIDF appropriately. This makes the application of the existing conventional PID parameter tuning methods a lot easier, and stability and robustness of the system are improved simultaneously due to the DIDF inserted.

High Precision Control of a Walking Piezoelectric Motor in Bending Mode
Zhenishbek Zhakypov, Edin Golubovic, Tarik Uzunovic, Asif Sabanovic
Sabanci University, Turkey

This work presents functional description of a walking piezoelectric motor and its control in bending mode. For this purpose a dynamical model of the actuator is derived based on simple mass spring damper system. Identification experiments are conducted to verify the theoretical kinematics of the bimorph legs presented in previous works. These experiments demonstrate approximately linear relation between the legs displacement in x and y planes to the applied voltages. Based on these results a PI controller followed by Hadamard transformation is proposed as a controller scheme. Experimental results for staircase and sinusoidal tracking references reveal precise positioning down to few nano-meters.
Event-Triggered Control of Multi-Agent Systems with Suboptimal Triggering
Yuan Fan¹, Gang Feng²
¹Anhui University, China; ²City University of Hong Kong, Hong Kong
In this paper the suboptimal event-triggered control problem of multi-agent systems is studied. Firstly the combinational measurement approach is presented. Compared with the existing works, agents are only triggered at their own event time instants in this approach, which reduces the amount of controller updates in practice. Then based on the convergence proof of the system, we have investigated the system average cost and proposed a suboptimal approach to determine the triggering condition. The effectiveness of the proposed strategy is illustrated by numerical examples.

Vector Control Lyapunov Functions as a Tool for Decentralized and Distributed Control
Zhong-Ping Jiang², Karafyllis Iasson²
¹Polytechnic Institute of New York University, USA; ²Technical University of Crete, Greece
This paper presents a novel tool based on vector control Lyapunov functions for complex nonlinear control systems. It is shown that the existence of a vector control Lyapunov function is a necessary and sufficient condition for the existence of a smooth globally stabilizing feedback. This main result is then applied to the problem of designing globally stabilizing feedback laws for nonlinear systems. Practically checkable sufficient conditions are proposed to guarantee the existence of a smooth globally stabilizing feedback law.

Containment Control of Discrete-Time Multi-Agent Systems Based on Delayed Neighbors’ Information
Shuai Liu¹, Lihua Xie¹, Huanshui Zhang¹
¹Nanyang Technological University, Singapore; ²Shandong University, China
This paper considers the containment control problem for multi-agent systems with multiple leaders. A distributed control protocol is designed so that the states of the followers converge to the smallest convex hull containing the states of all the leaders. The result is extended to the moving leaders case. Two level protocols are provided such that the leaders can achieve a formation while the followers converge into the convex hull formed by the leaders. The control protocols are based on neighbours’ control inputs. A sufficient condition on the control gain is proposed to guarantee the convergence. A numerical example is given to demonstrate the result.

Adaptive Flocking Control of Multiple Nonholonomic Mobile Robots with Limited Communication Ranges
Wang Wei¹, Changyun Wen², Jiangshuai Huang³
¹Tsinghua University, China; ²Nanyang Technological University, Singapore
The paper considers the flocking of multiple nonholonomic mobile robots under the situations that all parameters of the robot are unknown and the robots are of limited communication range. Backstepping technique based distributed control schemes are proposed by introducing a $\mathcal{P}\mathcal{S}$-time differential function. This function is embedded into a potential function to design control algorithms for flocking control. The controllers guarantee that no collisions between any two robots occur, and no switching of controllers is needed. The size of the flock is bounded and the robots will go to an equilibrium set as time go to infinity. Simulations illustrate the results.

Rendezvous of Nonholonomic Multiple Unicycles with Connectivity Maintenance
Yutian Mao, Hao Fang, Lihua Dou, Jie Chen
Beijing Institute of Technology, China
In this paper, a rendezvous problem is investigated for repositioning and reorienting a network of multiple unicycles with nonholonomic kinematics. In contrast to previous approaches to the problem, decentralized and bounded timevarying continuous control protocols are developed by utilizing dipolar navigation functions which integrate consensus requirement, connectivity maintenance and collision avoidance, simultaneously. It is shown that the proposed bounded controllers could enable the group of unicycles to converge to the common position with a common orientation while preserving the network connectivity during the evolution when the underlying network is initially connected. Finally, nontrivial simulations are presented to verify the effectiveness of the proposed control algorithms.

Consensus Conditions of Continuous-Time Multi-Agent Systems with Relative- State-Dependent Measurement Noises and Matrix-Valued Intensity Functions
Tao Li¹, Fuke Wu², Ji-Feng Zhang¹
¹Chinese Academy of Sciences, China; ²Huazhong University of Science and Technology, China
In this paper, we consider the distributed consensus of high-dimensional first-order agents with relative-state-dependent measurement noises. Each agent can measure or receive its neighbors’ state information with random noises, whose intensity is a nonlinear matrix-valued function of agents’ relative states. By the tools of stochastic differential equations and
algebraic graph theory, we give sufficient conditions to ensure mean square and almost sure consensus and the convergence rate and the steady-state error for average consensus are quantified.

**Improvement on Adaptive Forward Prediction Controller Using A Direct-Compensation Technique**

Wei De Xiao, Jia-Ying Tu, Chih Ying Chen  
*National Tsing Hua University, Taiwan*

Hybrid testing method of dynamically substructured system is used for performance evaluation of engineering systems. During the tests, an entire engineering system is decomposed into numerical (software) and physical (hardware) substructures. Linear and well-understood parts are simulated numerically, and uncertain specimens are tested physically. The success of the tests relies on a high-quality controller to cancel the unwanted dynamics introduced by actuators within the physical substructures, thus synchronizing the numerical and physical responses at the interface. Delay compensation techniques are commonly used in dealing with the substructuring control issues. This paper proposes a new direct-compensation strategy to define the initial condition of an adaptive delay-prediction controller, without using a priori information about the tested components’ parameters. Meanwhile, singular value decomposition method is applied to the control synthesis procedure, in order to reduce the numerical sensitivity of the controller, providing with the possibility of achieving a high-level accuracy of the tests. Experimental results are included, which favorably verify the proposed improvement strategies.

**Adaptive Control Using Multiple Parallel Dynamic Neural Networks**

Chao Jia, Xiaoli Li, Dexin Liu, Dawei Ding  
*University of Science and Technology Beijing, China*

The control problem of an unknown nonlinear dynamic system which contains the abrupt changes of parameters is concerned. Multiple models based on dynamic neural networks are used to approximate the dynamic character of unknown system. Different controllers based on these models and an effectively switching mechanism are applied to an unknown system to trace a reference trajectory. Further, we propose different switching and turning schemes for adaptive control which combine fixed and adaptive models. From the simulation, it can be shown that the multiple model adaptive control method proposed in this paper can improve the control performance greatly compared with the conventional adaptive control.

**A Data-Driven Methodology for Solving the Control Strategy of Descriptor Systems**

Daqing Zhang, Mengmeng Li, Jinna Li  
1. *University of Science and Technology Liaoning, China*; 2. *Shenyang Institute of Automation, Chinese Academy of Sciences, China*

This paper is concerned with the reinforcement learning methods for the discrete time descriptor systems. An algorithm, as well as its theoretical basis, is presented. The algorithm can generate the optimal controller for the target descriptor system only by the measured input and output data, with no need of the information about the system state and system matrices. The algorithm can work well not only when the system index is equal or less than one, but also can work well when the index is greater than one. Simulation indicates that the presented method can solve the optimal control problem well for descriptor systems when the system model is not exactly known, but the input and output data can be measured.

**FRIT and RLS-Based Online Controller Tuning and Its Experimental Validation**

Yuji Wakasa, Ryo Azakami, Kanya Tanaka, Shota Nakashima  
*Yamaguchi University, Japan*

This paper proposes an online type of controller parameter tuning method by modifying the standard fictitious reference iterative tuning (FRIT) method and by utilizing the so-called recursive least-squares (RLS) algorithm, which can cope with variation of plant characteristics adaptively. As used in many applications, the RLS algorithm with a forgetting factor is also applied to give more weight to more recent data, which is appropriate for adaptive controller tuning. Moreover, we extend the proposed method to online tuning of the feedforward controller of a two-degree-of-freedom control system. Finally, experimental results are provided to demonstrate the effectiveness of the proposed FRIT and RLS-based online controller tuning method.
A Lyapunov Method Based Multiple-Model Adaptive Actuator Failure Compensation Scheme for Control of Near-Space Vehicles

Chang Tan¹, Gang Tao², Xuelian Yao¹, Bin Jiang¹
¹Nanjing University of Aeronautics and Astronautics, China; ²University of Virginia, USA

In a recent paper [7], a multiple-model adaptive actuator failure compensation control scheme is proposed for the control of a near-space vehicle, using the gradient algorithm, to achieve fast and accurate actuator failures compensation. In this paper, a new multiple-model adaptive actuator failure compensation control scheme is developed for nonlinear systems motivated from a near-space vehicle control application. Such a design also employs multiple controllers based on multiple-model failure estimations and a control switching mechanism, based on finding the minimal performance cost index, to select the most appropriate controller. Different from [7], each estimator is designed based on the Lyapunov method, which ensures the system stability and desired tracking properties. Moreover, a smooth control are introduced to the multiple-model control system frame to avoid the discontinuity problem from the control switching, to widen the application of such design. Simulation results for a near-space vehicle dynamic model are presented to show the desired failure compensation performance.

Distributed Adaptive Output Agreement in A Class of Multi-Agent Systems

Veyesel Gazi
Istanbul Kemerburgaz University, Turkey

In this article we consider the distributed output agreement problem in a class of heterogeneous multi-agent dynamic systems composed of agents with nonlinear and uncertain dynamics. We develop a distributed direct adaptive fuzzy control methodology which using only local information guarantees achievement of agreement of the agent outputs despite the uncertainties in the agent dynamics. The performance of the proposed strategy is verified for various neighborhood topologies using representative numerical simulations.

24th June, Monday
14:00-16:00 at Maslagirt 2
MoB3 Discrete Event Systems
Session Chair : Qing-Shan Jia, Tsinghua University, China
Session Co-Chair: Eugenia Minca, Valahia University of Targoviste, Romania

Controlling Two Asynchronous Sequential Machines with One Corrective Controller

Jung Min Yang¹, Seong Woo Kwak²
¹Catholic University of Daegu, South Korea; ²Keimyung University, South Korea

Corrective control compensates the stable state specification of an asynchronous sequential machine so that the closed-loop system can imitate the behavior of a reference model. In this paper, we present a novel scheme of controlling two asynchronous sequential machines with one corrective controller. By virtue of structural characteristics of corrective controllers, we can combine two controllers designated for separate asynchronous machines into a combined controller, which still achieves the control objective. The existence condition for the corrective controller remains unchanged, but the size of the overall controller can be significantly reduced by the proposed scheme. We provide the design algorithm for the prosed combined controller and conduct a quantitative analysis on the size reduction of the controller.

Model Matching of Input/State Asynchronous Sequential Machines Using a One-Step Corrective Controller

Jung Min Yang
Catholic University of Daegu, South Korea

This paper addresses a feedback control methodology for asynchronous sequential machines. The control objective is model matching, namely designing a controller that compensates the closed-loop system so that it can match the behavior of a reference model. In particular, we propose a one-step corrective controller, which undergoes a minimum number of state transitions when operating the correction procedure. We present the existence condition and design procedure for the one-step corrective controller that realizes model matching with a given model. A controller with reduced state numbers requires a more strict condition on reachability of the considered machine than dynamic controllers. An illustrative example is provided for verifying the applicability of the proposed scheme.

Policy Iteration for Parameterized Markov Decision Processes and Its Application

Li Xia, Qing-Shan Jia
Tsinghua University, China

In a parameterized Markov decision process (MDP), the decision maker has to choose the optimal parameters which induce the maximal average system reward. However, the traditional policy iteration algorithm is usually inapplicable because the parameters choosing is not independent of the system state. In this paper, we use the direct comparison approach to study this problem. A general difference equation is derived to compare the performance difference under different parameters. We derive a theoretical condition that can guarantee the application of policy iteration to the parameterized MDP. This policy iteration type algorithm is much more efficient than the gradient optimization algorithm for parameterized MDP.
Finally, we study the service rate control problem of closed Jackson networks as an example to demonstrate the main idea of this paper.

**A Theoretical Approach of the Generalized Hybrid Model Based Control of Repetitive Processes**

Eugenia Minca¹,², Adrian Filipescu¹, Alina Voda¹,³
¹Valahia University of Targoviste, Romania; ²University "Dunarea de Jos" of Galati, Romania; ³Grenoble University Joseph Fourier, Romania

A generalized Synchronized Hybrid Petri Nets (SHPN) model based control of a hybrid repetitive processes is presented in this paper. The whole process has two components: one discrete and one continuous. Its evolution can be described by a set of repetitive tasks. The generalized SHPN model is associated to this hybrid system with N repetitive tasks. The generalized SHPN model is customized to an assembly/disassembly mechatronics line (A/DML), served by a wheeled mobile robot (WMR) equipped with robotic manipulator (RM). The behavior as a hybrid system appears during disassembly, when WMR with RM is used to transport the work parts from the disassembly locations to the storage location in order to be reused in assembly. The assembly can be modeled as discrete system events (DES). This hybrid system takes into consideration the distribution of the necessary tasks to perform the hybrid disassembly of the work parts, by synchronization between WMR equipped with RM and A/DML. An optimization approach of the cycle time, associated to the control of repetitive processes is also presented.

**A Discrete-Event Traffic Simulation Model for Multilane-Multiple Intersection**

Azura Che Soh¹, Rubiyah Yusof², Mohammad Hamiruce Merhaban³
¹Universiti Putra Malaysia, Malaysia; ²Universiti Teknologi Malaysia, Malaysia

In this paper, the model is simplified by proposing a decomposed queuing theory to multilane-multiple intersection. The concept of queuing theory looks promising due to its simplicity and its combination with standard approach techniques. This can expand the model to be more reliable in dealing with problem associated to multilane-multiple intersections. The proposed model is simple, flexible and fit to any real case study with different structure of topology. The traffic model is developed using discrete-event simulation (DES) framework for computation and analysis the model. Simulation results have shown good correlation between the proposed traffic model and data taken from real traffic situations, and have confirmed that the proposed modeling technique based on queuing theory and standard decomposition method can be realized. In addition, simulation results give a confirmation of the model capability to correctly predict traffic performance measures.

**A Self-Aligning Underwater Navigation System Based on Fusion of Multiple Sensors Including DVL and IMU**

Prashanth Krishnamurthy¹,², Farshad Khorrami¹,²
¹FarCo Technologies, Inc., USA; ²Polytechnic Institute of NYU, USA

An adaptive self-aligning underwater navigation system based on data fusion from a set of multiple sensors including a MEMS-based inertial measurement unit (IMU), a Doppler Velocity Log (DVL), a 3-axis magnetic compass, and a pressure sensor for depth measurement is proposed. These sensors are typically included as part of the standard sensory complement in Autonomous Underwater Vehicle (AUV) platforms. A generic estimation framework is developed that addresses both estimation of the kinematic state of the vehicle (including position, velocity, and orientation angles) as well as sensor parameters (including bias/mis-alignment parameters of IMU accelerometer and gyros, compass, and DVL). Detailed noise models of all the considered sensors are addressed in the development of the navigation system. The performance of the proposed system is demonstrated through simulation studies.

**Dynamical Average Consensus in Networked Linear Multi-Agent Systems with Communication Delays**

Jianqiang Hu¹, Jinling Liang¹, Fangbin Sun¹, Ping Li²
¹Southeast University, China; ²The University of Hong Kong, Hong Kong

In this paper, dynamical average consensus problem is studied for the networked identical linear multi-agent systems. A double coupling dynamical consensus protocol is proposed which is composed of the feedback of the protocol variables and the state variables. The protocol updates its information according to its own protocol communication topology which may be different from the state communication topology of the agents, and both of these two communication topologies are assumed to be balanced digraphs. Firstly, double topology protocol is analyzed for the system without communication delays. Then the protocol is extended to the case with time-varying delays. It is proved that all the nodes in the network can achieve dynamical average consensus asymptotically for appropriate communication delays. Numerical examples are given in the end of the paper to demonstrate the effectiveness of the theoretical results.
Second-Order Leader-Following Consensus of Multi-Agent Systems with Nonlinear Dynamics and Time Delay via Periodically Intermittent

Xiaoling Wang, Bo Liu, Housheng Su, Xiaofan Wang
North China University of Technology, China; Huazhong University of Science and Technology, China; Shanghai Jiaotong University, China

This paper investigates the second-order leader-following consensus of multi-agent systems with nonlinear dynamics and time delay by virtue of the periodically intermittent pinning control. All member agents and the virtual leader share the same nonlinear dynamics related to both the position information and the velocity information. Based on Lyapunov stability theory, some useful criteria are obtained to drive all the agents to achieve consensus. Finally, a numerical example is presented to illustrate the theoretical results.

Event-Triggered Control for Discrete-time Multi-agent Networks

Lulu Li, Daniel Ho, Yuanyuan Zou, Chi Huang, Jianquan Lu
City University of Hong Kong, Hong Kong; East China University of Science and Technology, China; Taiyuan University of Technology, China; Southeast University, China

In this paper, a new control strategy was proposed to deal with the discrete-time multi-agent consensus problem. Two types of protocols are discussed in this paper: i) networks of single-integrators without delay under centralized event-triggered control and ii) networks of single-integrators with delay under distributed event-triggered control. For each consensus protocol, we prove that the multi-agent network will achieve consensus asymptotically. Numerical examples are provided to demonstrate the effectiveness of the obtained theoretical results.

Fuzzy Sampled Controller Design for Consensus of Multi-agent Networks with Varying Connections

Wenjun Xiong, Wenwu Yu, Jinhu Lu, Xinghuo Yu
Switzerland Petroleum University, China; Southeast University, China; Chinese Academy of Sciences, China; RMIT University, Australia

T-S fuzzy models are first presented to describe multiagent networks (MANs) with varying connections. The nodes of each T-S fuzzy model are rearranged so that the global fuzzy model is decomposed into independent and small-scale fuzzy models. It is shown that the consensus of the global fuzzy model is equivalent to that of its corresponding small-scale fuzzy models in which the sampled controller is applied. A sufficient condition is derived to ensure the consensus of the sampled controlling fuzzy models.

Consensus Control of Switching Directed Networks with General Linear Node Dynamics

Guanghui Wen, Wenwu Yu, Jinde Cao, Guoqiang Hu, Guanrong Chen
Southeast University, China; Nanyang Technological University, Singapore; City University of Hong Kong, Hong Kong

Distributed consensus control for multi-agent systems with general linear node dynamics and switching balanced directed topologies is addressed in this paper. By using tools from algebraic graph theory and switching systems theory, it is proved that distributed consensus in the closed-loop linear multi-agent systems on such a network can be achieved if the feedback gain matrix of the protocol is appropriately designed and the coupling strength among neighboring agents is larger than a threshold value. The convergence rate for the achievement of consensus is further discussed. Interestingly, it is found that an arbitrarily given large convergence rate can be guaranteed if each agent is controllable. The proposed results are verified through numerical simulations.

Cluster Consensus of Boolean Multi-Agent Systems

Fangfei Li, Yao Chen, Jinhu Lu, David J. Hill
Chinese Academy of Sciences, China; Australian National University, Australia

Consensus of the multi-agent systems (MASs) is ubiquitous in nature. Over the past decade, consensus of the MASs has received an increasing attention from various disciplines. Inspired by the cluster consensus of the discrete-time MAS, this paper aims at exploring the cluster consensus of the Boolean MAS and applies it to modeling the synchronous flashing of fireflies. Based on the graph theory and the Boolean matrix analysis, two cluster consensus criteria are established for the Boolean MASs with fixed and switching topologies. Furthermore, numerical simulations are also given to validate the effectiveness of these proposed criteria.
Nonholonomic Control of Distance-based Cyclic Polygon Formation
Hyo-Sung Ahn, Byung-Hun Lee, Seung-Ju Lee, Kwang-Kyo Oh, Myoung-Chul Park
Gwangju Institute of Science and Technology (GIST), South Korea

Inter-agent distance-based formation is an interesting issue that has been recently studied. We propose a control strategy based on inter-agent cyclic formulation of a unicycle-like nonholonomic model. Graph considered in this paper is directed one. Each agent maintains a desired distance with a neighbor agent. Under sliding control technique, a sequence of control inputs forces the configuration to be changed to an equilibrium manifold.

A Control System Based On Data Exchange Using Ethernet And CANBUS for Deep Water AUV
Xinjing Huang, Yibo Li, Shijiu Jin
Tianjin University, China

There is a large amount of real-time information exchange between mounted devices and the respective control nodes and among different control nodes in Autonomous Underwater Vehicle (AUV). Either using CANBUS alone or using Ethernet alone for AUV control system, there are major drawbacks. This paper applies both of these two methods in the AUV’s data communication and control system. Communication among different control nodes as well as among some equipment and nodes applies Ethernet while communication between the motion control node and the actuators applies CANBUS. This not only ensures the feasibility of the huge amount of data transmission but also ensures the reliability and real-time of some communication. The scalability of the system is very strong, but the complexity of the whole system does not increase. Tests show that this approach is feasible.
State Estimation Subject to Random Network Delays without Time Stamping

Yuanhua Yang¹, Minyue Fu¹, Huanshui Zhang¹
¹ShanDong University, China; ²University of Newcastle, Australia

The discrete-time state estimation problem is studied for networked control systems subject to random network delays without time stamping. A new time delay model is presented which allows the transmitted data to be received in bursts. Under the assumption that the data bursts are not out of order, we derive the optimal linear estimator which guarantees an unbiased estimate with minimum and uniformly bounded estimation error covariance. The estimator gains can be derived by solving a set of recursive discrete-time Riccati equations. A simulation example shows the effectiveness of the proposed algorithm.

24th June, Monday
14:00-15:40 at Barbaros A
MoB6 Energy Technology (I)
Session Chair: Saad Mekhilef, University of Malaya, Malaysia
Session Co-Chair: Ching-Tsan Chiang, Chien Hsin University of Science and Technology, Taiwan

Novel Voltage Control of 18 Level Multilevel Inverter
Saad Mekhilef
University of Malaya, Malaysia

This paper presents a three-stage eighteen-level inverter design with a novel control method. The inverter consists of a series connected main high-voltage, medium-voltage and low-voltage stages. The high voltage stage is made of a three-phase, six-switch conventional inverter. The medium and low voltage stages are made of three-level inverters constructed by H-bridge units. The proposed control strategy assumes a reference input voltage vector and aims to operate the inverter in one state per sampling time to produce the nearest vector to that reference. The control concept is based on representing the reference voltage in 60°-spaced two axis coordinate system. In this system, the inverter vectors’ dimensions are integer multiples of the inverter’s dc voltage and the expression of the inverter’s vectors in terms of its switching variables is straightforward. Consequently, the switching signals can be obtained by simple fixed-point calculations. The approach of the proposed control strategy has been presented, the transformed inverter vectors and their relation to the switching variables have been defined, and the implementation process has been described. The test results verify the effectiveness of the proposed strategy in terms of computational efficiency as well as the capability of the inverter to produce very low distorted voltage with low switching losses.

Control The Photovoltaic Grid-Connected System Using Fuzzy Logic and Backstepping Approach
Nguyen Gia Minh Thao, YKenko Uchida
Waseda University, Japan

This paper presents a comprehensive method to design a compatible controller system for the photovoltaic (PV) single-phase grid-connected system. The demonstrative PV system in this study consists of four 250W solar panels with a nominal total power of 1 kW, a non-inverting buck-boost DC-DC converter, and a DC-AC inverter, including a LCL output filter. Main objectives of the PV system in use are threefold: tracking and operating at the maximum power point (MPP) of the PV array, regulating the DC link voltage to 200 V, and delivering the power to the 110V/60Hz electric grid with unity power factor (PF). To fulfill three above goals respectively, the designed controller system is composed of three major modules. In which the first is the MPPT Controller module, using an improved incremental conductance (INC) algorithm based on fuzzy logic. Another is the DC Link Voltage Regulator module constituted by a PI-Fuzzy hybrid controller. And the last is the Current Controller module based on the backstepping approach. Simulations show that the proposed controller system completely fulfills listed aims even when the solar radiation and temperature change suddenly.

Extremely Short-Term Wind Speed Prediction Based on RSCMAC
Ching-Tsan Chiang
Chien Hsin University of Science and Technology, Taiwan

Wind power is an intermittent and unstable energy. In recent years, wind power system installation fields are getting more and more, the installation capacities are getting larger and larger, therefore, the stability of the wind power system is becoming very important. This research completed building a wind power system model and developed extremely short term wind power forecasting system. In the part of building wind turbine model, it is based on realistic wind turbine operational data and applies to a traditional wind turbine mathematical model to find the best Betz coefficient of a wind turbine model Vestas 80 (Denmark), then based on Recurrent S_CMAC_GBF (RSCMAC) to build a new RSCMAC wind turbine model. Comparison confirmed the better results of RSCMAC wind turbine model achieved. In the part of developing extremely short term wind speed forecasting system, the meteorological stations were set up around the forecasting fields to collect relevant information and based on RSCMAC to develop an extremely term wind speed forecasting system; the results show the forecast feasibility and effect. In the future, this forecasting system can be applied as the reference for the application of wind farm evaluation or wind energy prediction.
A New PID Auto-Tuning Strategy with Operational Optimization for MCFC Systems
Yujin Cheon¹, Donghyun Lee¹, Su Whan Sung², In-Beum Lee³
¹POSTECH, South Korea; ²Kyungpook National University, South Korea
High temperature fuel cell systems should provide appropriate power output levels to be practical in a grid-connected system. Designing control systems to track the power demand are important and challenging since integrated fuel cell systems have nonlinear and highly complex dynamic. This paper presents a new strategy of PID auto-tuning which combined with an operational optimization for MCFC systems to track the power demand with high efficiency.

Digital AFC Control of a Three-Phase Three-Wire Unity-Power-Factor PWM Rectifier
Marcos Orellana, Robert Grin
Universitat Politecnica de Cataluna (UPC), Spain
Nowadays, ac/dc power converters must fulfill more and more design constraints with respect to the electrical grid: harmonics reduction, operation with sags and swells and/or high grid impedances, etc. This is a challenge for the controllers, since they must be robust enough to ensure the stability of the system, specially when working the conditions are not the ideal ones. In this paper, a discrete-time control technique based on Adaptive Feed-forward Cancellation (AFC) is proposed for a three-phase three-wire rectifier with a LCL input filter. The continuous-time design method for resonators has been translated into the discrete-time domain. Thus, the controller has been entirely designed in discrete-time, avoiding approximate conversions of the controller from the continuous-time domain. Besides, the usual unit computational delay in sampled-data control systems is taken into account. The simulation results show that this kind of resonant control is not only robust, but also presents a good performance.

Adaptive Consensus of Multi-agent Systems with Unknown Nonlinear Dynamics
Hui Yu¹, Xiaohua Xia²
¹China Three Gorges University, China; ²University of Pretoria, South Africa
In this paper, the consensus problem of multiagent systems with non-identical unknown nonlinear dynamics following an unknown and nonlinear leader is studied. By parameterizations of unknown nonlinear dynamics of all agents, decentralized adaptive consensus algorithms are proposed in networks with fixed and switching topologies by incorporating local consensus errors in addition to relative position feedback. Analysis of stability and parameter convergence of the proposed algorithm are conducted based on algebraic graph theory, Lyapunov theory and Riccati inequalities. Finally, examples are provided to validate the theoretical results.

Quantized-Data Consensus of Second-Order Multi-Agent Systems with Directed Topology
Chao Wang, Weiwei Mao, Xiaobo Li, Weisheng Chen, Jing Li
Xidian University, China
This paper studies the consensus problem for linear discrete-time second-order multi-agent system with quantized data under directed topologies. The necessary and sufficient conditions for consensus are given by using a quantized consensus protocol via positions and velocities. Also, the final consensus value is obtained if the design parameters satisfy the conditions of the quantized consensus and the length of quantization interval tends to zero. Furthermore, the observer-based quantized consensus is investigated as well when the velocities of agents are unavailable. Simulation examples are provided to verify and illustrate the theoretical results obtained in this paper.

Distributed Circumnavigation by Unicycles with Cyclic Repelling Strategies
Ronghao Zheng¹, Zhiyun Lin², Minyue Fu³, Dong Sun¹
¹City University of Hong Kong, Hong Kong; ²Zhejiang University, China; ³The University of Newcastle, Australia
The distributed circumnavigation problem, in which the task is to circumnavigate a target of interest by a network of autonomous agents, has many applications in security and surveillance, orbit maintenance, source seeking, etc. This paper deals with the circumnavigation problem using a team of nonholonomic unicycles. A novel distributed solution is proposed based on cyclic repelling strategies to achieve a circular motion around a target in a circular formation. This new approach considers minimum number of information flow links and local measurements only, yet a uniform distribution of unicycles rotated around the target is accomplished. The asymptotic collective behavior is analyzed based on the block diagonalization of circulant matrices by a Fourier transform. Simulation results also verify the validity of the proposed control algorithm.
Coordinated Adaptive Control for Formation Flying Vehicles with a Time-Varying Orbital Velocity
Yang-Yang Chen, Yuping Tian
Southeast University, China
This article considers the problem of directing a family of nonholonomic vehicles to formation flying a set of closed convex planar orbits and approach a time-varying reference orbital velocity in a three-dimensional (3D) space. A novel coordinated adaptive control law based on local neighbor-to-neighbor information is proposed to estimate the desired orbital velocity so that the assumption that every vehicle in the family has access to the reference in the literature is removed. We show how the geometric extension design, projection tracking method and consensus-based technique can be combined together to construct the formation flying controller under the bidirectional commutation topology. Simulation results demonstrate the effectiveness of the proposed approach.

H_{infty} Consensus Tracking in Sensor Networks with Time-Varying Sensing Period
Ya Zhang, Yuping Tian
Southeast University, China
This paper studies the H_{infty} consensus tracking of general linear dynamical target with unknown disturbance input and time-varying sensing period. From a series of system transformations the consensus tracking problem is converted to the robust stability problem of an uncertain delayed subsystem. By using Lyapunov-Krasovskii functional analysis, an LMI-based H_{infty} consensus tracking condition is obtained. The condition consists of only four LMIs. Then an allowable upper bound of sensing period is provided by solving the H_{infty} stabilization problem. Numerical examples are given to illustrate the results.

Bearing Angle Measurement Based Cooperative Pursuit-Evasion Game in Non-convex Environments
Di Guo, Gangfeng Yan, Zhiyun Lin
Zhejiang University, China
This paper addresses a cooperative pursuit-evasion game in non-convex environments, for which a team of pursuers are equipped with onboard bearing angle measurement sensors. Different from many existing work, our work assumes that the agents have no global coordinate system and thus can not measure the absolute positions, but it is expected for the pursuers to estimate the positions of other agents in their local frames. Based on the estimated positions, a distributed computation method is developed where a series of Hamilton-Jacobi-Bellman (HJB) equations are solved cooperatively in order to determine the control input for every pursuer with the help of limited information exchange among pursuers. We demonstrate the effectiveness of the proposed scheme by simulations.
Minimum Energy Trajectory Planning Method for Robot Manipulator Mounted on Flexible Base
Akira Abe
Asahikawa National College of Technology, Japan

This paper proposes a minimum energy trajectory planning method with residual vibration reduction for a robot manipulator mounted on flexible base, in which a point-to-point motion task of the manipulator is considered. In the proposed method, the joint angle of the robot manipulator is generated by radial basis function networks (RBFNs). The maximum residual vibration amplitude and operating energy are adopted as the objective functions, and then, the RBFNs are tuned by an elitist non-dominated sorting genetic algorithm (NSGA-II). The trajectory obtained using the proposed method can suppress the residual vibration of the flexible base in energy conservation. Results obtained from simulations reveal a trade-off relationship between the residual vibration amplitude and the operating energy. Furthermore, the validity of the proposed method is confirmed experimentally.

A Method for Decentralized Formation Building for Unicycle-like Mobile Robots
Andrey Savkin¹, Chao Wang¹, Ahmad Baranzadeh¹, Zhiyu Xi¹, Hung Nguyen¹
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The paper presents a method for decentralized flocking and global formation building for a network of unicycles described by the standard kinematics equations with hard constraints on the vehicles linear and angular velocities. We propose decentralized motion coordination control algorithms for the robots so that they collectively move in a desired geometric pattern from any initial position. There are no predefined leaders in the group and only local information is required for the control. The effectiveness of the proposed control algorithms is illustrated via computer simulations and experiments with real robots.

Investigation of Interactions between Mechanical and Electrical Components of a Motion Platform
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While modelling control systems with mechanical components driven by electrical motors it is usually assumed that the torque generating (electrical) sub-system has negligible dynamics and remaining study is based on this assumption. This paper is focused on investigation of the validity of this assumption. For this purpose, the interactions between mechanical and electrical components of a system consisting of an electrical motor connected to a mechanical load has been investigated by employing a simplified, linear model. Besides the analysis using this model, data collected via experiments on real hardware was processed and compared with the theoretical findings.

The Construction method of GIS for Autonomous Vehicles
Meiling Wang, Yong Yu, Qizhen Wang, Yi Yang, Tong Liu
Beijing institute of technology, China

In order to achieve the dynamic construction of GIS which shows the environment information around the driving autonomous vehicle, this paper introduces a method, including the data fusion of laser radar, GPS and IMU, the registration of point cloud data, the rasterisation and the extraction of isosurface. The geographic objects which influence the driving characteristics of the autonomous vehicle can be extracted from the processed isosurface according to the analysis of the feature of the autonomous vehicle. This construction method improves some limited ability of GIS, which can provide the navigation information for the autonomous vehicle.

Control for Quadruped Robots in Trotting on Horizontal and Slanted Surfaces
Jeong Hoon Lee, Jong Hyeon Park
Hanyang University, South Korea

The objective of this work is to make a quadruped robot trot on horizontal and slanted surfaces through a natural transition of motion. For this, control methods that are different from the ones devised for robot trotting on horizontal surface are required. The control methods proposed in this paper consist of two parts: natural movement of the center point of foot trajectory and the impedance control based on variable impedance parameters. The changes of the center point are generated for a gradual and continuous adaptive foot motion. And, the variable impedance control and leg controls are used to maintain the stability of locomotion as well as to reduce the yawing motion. Motion of a quadruped robot with the proposed control methods were simulated and their performance were verified through the simulations.
Velocity Estimation and Control of 3-DOF Helicopter based on Optical Flow
Lianhua Zhang, Hao Liu, Zongying Shi, Yisheng Zhong
Tsinghua University, China

This paper presents an angular velocity estimation method based on optical flow to address the hovering and angle tracking control problem for a three degree-of-freedom (3-DOF) lab helicopter. An analytical expression of the travel angular velocity is deduced based on optical flow. Then, a controller consisting of a feedforward controller and a linear quadratic regulation (LQR) state feedback controller is designed. Experiment results on the lab helicopter demonstrate the validity of the angular velocity estimation method and the LQR control strategy.

Approximate Solutions to the Hamilton-Jacobi Equations for Generating Functions: the General Cost Function Case
Zhwei Hao1, Kenji Fujimoto1, Yoshikazu Hayakawa2
1Nagoya University, Japan; 2Kyoto University, Japan

Recently, the method based on generating functions is proposed for nonlinear optimal control problems. For a finite time optimal control problem with given boundary condition, once a generating function for a fixed boundary condition is obtained, any optimal trajectory of the same system for different boundary conditions can be generated easily. An algorithm to compute an approximate solution to the Hamilton-Jacobi equation with respect to the generating function for a nonlinear optimal control problem is developed in this paper. Numerical examples illustrate the effectiveness of the proposed method.

On a trolley-like problem in the presence of a nonlinear friction and a bounded fuel expenditure
Ivan Samylovskiy
Lomonosov Moscow State University, Russia

We consider a problem of maximization of the distance traveled by a material point in the presence of a nonlinear friction under a bounded thrust and fuel expenditure. Using the maximum principle we obtain the form of optimal control and establish conditions under which it contains a singular subarc. This problem seems to be the simplest one having a mechanical sense in which singular subarcs appear in a nontrivial way.

CRS and PS-Optimised PID Controller for Nonlinear, Electrohydraulic Suspension Systems
Jimoh Pedro, Akintunde Olorotimi Dahunsi, Montaz Ali, Muhammed Dangor
University of the Witwatersrand, South Africa

The compromise between ride comfort, suspension travel, road holding, vehicle handling and power consumption determines the success of an active vehicle suspension system (AVSS). The simplicity of Proportional-Integral-Derivative (PID) controllers has made it the controller of choice for many mechatronic systems including AVSS. This investigation studies the effectiveness of optimal control policies such as Pattern Search (PS), and Controlled Random Search (CRS)-based PID controllers in dealing with the inherent trade-offs of AVSS. A nonlinear servo-hydraulic quarter-car AVSS is considered in this article. The success of these optimal PID controllers may provide a contemporary foundation in selecting optimal gains PID for a control system, which at the moment is a rather rigorous and time consuming process. The objective function is chosen such that each of the AVSS trade-offs are addressed. The PS routine improved significantly from the manually tuned case in terms of ride comfort and settling time, but exhibited weaker characteristics in terms of road holding and transient behaviour, which implies that its solution may have been caught in a local minimum.

Realizability of n-Port Resistive Networks with 2n Terminals
Michael Z. Q. Chen1, Kai Wang2, Minghui Yin3, Chanying Li1, Zhiqiang Zuo4, Guanrong Chen5
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In this paper, we consider the realizability problem of n-port resistive networks containing 2n terminals. A necessary and sufficient condition for any real symmetric matrix to be realizable as the admittance of an n-port resistive network containing 2n terminals is obtained. The condition is based on the existence of a parameter matrix. We then focus on a three-port resistive network containing six terminals. A necessary and sufficient condition is derived for any real symmetric matrix to be realizable as the admittance of a three-port resistive network containing six terminals and at most five positive elements, whose topological structure is properly restricted.
Numerical Solution for a Class of pursuit-evasion Problem in Low Earth Orbit
Songtao Sun, Qiuhua Zhang
Harbin Institute of Technology, China
A two spacecraft pursuit-evasion problem in a low earth orbit with two payoffs, is investigated by an integrated approach using the semi-direct nonlinear programming and the multiple shooting method. The problem is formulated by a zero-sum differential game. The miss distance at a fixed terminal time and the capture time are defined as the payoffs. The pursuer strives to minimize the payoff while the evader attempts to maximize it. Semi-direct nonlinear programming serves as a preprocessor in which control is parameterized in piecewise form. Its solution is then used as the initial values for the multiple shooting method and thus a refined solution is obtained for a two-point boundary-value problem arising from the necessary conditions. The optimal trajectory and optimal control using the semi-direct nonlinear programming and the multiple shooting method are computed and compared. Numerical equivalence of the semi-direct method and the hybrid method with respect to the differential game is evidenced by a realistically modeled pursuit-evasion test case. This proposed integrated approach is shown to be robust, accurate and more efficient than using only a single method.

Non-fragile Fuzzy Control Design for Nonlinear Time-Delay Systems
Baharak Makki, Bahador Makki, Hamid Reza Karimi
1University of Agrid, Norway; 2University of Bremen, Germany
In this paper, a non-fragile fuzzy control design is proposed for a class of nonlinear systems with mixed discrete and distributed time delays. The Takagi and Sugeno (T-S) fuzzy set approach is applied to the modelling of the nonlinear dynamics, and a T-S fuzzy model is constructed, which can represent the nonlinear system. Then, based on the fuzzy linear model, a fuzzy linear controller is developed to stabilize the nonlinear system. The control law is obtained to ensure stochastically exponentially stability in the mean square. The sufficient conditions for the existence of such a control are proposed in terms of certain linear matrix inequalities.

Dual Estimation of Attitude and Parameters Considering Vibration based on GPS and IMU
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Attitude determination is one of main problems in flight mechanics and plays an important role in the assessment of flight security and flight quality. However, attitude determination is strongly coupled with the estimation of unknown vibration parameters when the output of the inertial measurement unit (IMU) is corrupted by the vibration induced by the piston engine. The unknown vibration parameters in the attitude dynamics can degrade attitude accuracy of dead reckoning. In this paper, a dual estimation of attitude and parameters considering vibration is investigated for small UAV. The dynamic model contained attitude and parameters is established by state augmentation, and the observations are chosen as GPS velocity and heading. In order to employ hybrid extended kalman filter for dual estimation, Jacobian matrices are formulated by linearizing the estimation model to propagate and update error variance. Since joint state estimation has tremendous computational loads, based on matrix blocking a state and parameter separated estimation is proposed to decouple the estimation of attitude and parameters. Simulation results show that the proposed method can give high precision attitude than the common filter without considering vibration.

A new clustering technique for the identification of PWARX hybrid models
Zeineb Lassoued, Kamel Abderrahim
University of Gabes, Tunisia
This paper addresses the problem of clustering-based procedure for the identification of PWARX models. It consists in estimating both the parameter vector of each sub-model and the coefficients of each partition. It exploits three main techniques which are clustering, linear identification and pattern recognition. The performance of this approach depends on the used clustering technique. However, most of existing methods are based on classical approaches which are sensible to poor initialization and suffer from the presence of outliers. To overcome these problems, we propose to exploit the Chiu’s clustering technique. Simulation results are presented to illustrate the performance of the proposed method.

VB-AQKF-STF: A Novel Linear State Estimator for Stochastic Quantized Measurements Systems
Quanbo Ge, Chenglin Wen, Xiangfeng Wang, Xingfa Shen
1Hangzhou Dianzi University, China; 2Nanjing University, China
Networked state estimation with adaptive bit quantization is studied for linear systems in this paper, for which sensor measurements are locally quantized and the taken quantized messages are sent to a processing center. Strong tracking filtering (STF) technology and variational Bayesian (VB) method are jointly adopted to deal with unknown variance of
stochastic quantization error vector. A kind of novel quantized state estimator VB-AQKF-STF is proposed to effectively improve quantized estimate accuracy and performance to deal with sudden change of state. The variance of the quantization error is approximated by a known upper bound, and the STF with a time-variant fading factor is used to reduce influence of the approximation and achieve strong tracking performance for the inaccurate system model. The VB method is applied to dynamically evaluate the variance of the integrated message noise. In nature, this variance estimate essentially provides a basis for the quantized strong tracking filter. Two simulation examples are demonstrated to validate the proposed quantized estimators.

A Frequency-based Method for Complete Identification of Some Types of Wiener-type Plants Based on Relay Feedback
Selma Hanjalic, Zeljko Juric, Hamza Sehovic, Branislava Perunicic
University of Sarajevo, Bosnia and Herzegovina
This paper proposes a new closed loop frequency based method for a parametric identification of some types of Wiener-type nonlinear plants. It provides a parametric model of the linear part of the plant, and a point by point relationship between input and output of the nonlinear part of the plant. Two approaches are proposed for the identification of the nonlinear part. The first approach is slower, but it does not require any additional equipment expect the relay. The second approach is much faster, but it requires some additional equipment.

Wavelet Network based Online Sequential Extreme Learning Machine for Dynamic System Modeling
Dhiadeen Salih, Samsul Bahari Mohd Noor, Mohammad Hamiruce Merhaban, Raja Kamil
University Putra Malaysia, Malaysia
Wavelet network (WN) has been introduced in many applications of dynamic systems modeling with different learning algorithms. In this paper an online sequential extreme learning machine (OS-ELM) algorithm adopted as training procedure for wavelet network based on serial-parallel nonlinear auto-regressive exogenous (NARX) model. The proposed model used as system identification for nonlinear dynamic systems. The main advantage of OS-ELM over conventional algorithms is the ability of updating network weights sequentially through data sample-by-sample in a single learning step. This attains good performance at extremely fast learning. The initial kernel parameters of WN played a big role to ensure fast and better learning performance. A simulation of proposed model applied to nonlinear dynamic systems to compare identification accuracy and fast learning ability.

Performance Analysis of MPC Based on Structures Subject to No-Model Input/Output Combinations
Leandro Massaro, Alain Potts, Claudio Garcia
University of Sao Paulo, Brazil
An analysis of the benefits over MPC performance obtained through the use of a method to detect no-model IO (input/output) combinations for open and closed-loop in multiple input multiple output (MIMO) systems is performed. Traditional approaches to IO selection are usually performed after the plant model is already characterized, which can lead to model-plant mismatch. The approach herein presented is applied during the pre-identification stage, in order to provide previous information to the following stages. A study case involving identification of a 2 x2 MIMO system is discussed.

Robust adaptive dynamic programming for optimal nonlinear control design
Yu Jiang, Zhong-Ping Jiang
Polytechnic Institute of New York University, USA
This paper studies the robust optimal control design for uncertain nonlinear systems from a perspective of robust adaptive dynamic programming (robust-ADP). The objective is to fill up a gap in the past literature of ADP where dynamic uncertainties or unmodeled dynamics are not addressed. A key strategy is to integrate tools from modern nonlinear control theory, such as the robust redesign and the backstepping techniques as well as the nonlinear small-gain theorem, with the theory of ADP. The proposed robust-ADP methodology can be viewed as a natural extension of ADP to uncertain nonlinear systems. A practical learning algorithm is developed in this paper, and has been applied to a sensorimotor control problem.

On Modeling of Tall Linear Systems with Multirate Outputs
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Motivated by problems of modeling high dimensional time series, this paper considers time-invariant, discrete-time linear systems which have a larger number of outputs than inputs, with the inputs being independent stationary white noise sequences. Moreover, different outputs are measured at different rates (in economic modeling, it is common that
some variables are measured monthly and others quarterly. In particular, the paper focuses on the case where the number of measurements is extremely large compared to the number of inputs. In the current paper, our ultimate goal is to identify the parameter matrices of such systems from outputs covariance data. To achieve this main goal and avoid excessively high dimensionality in the model, we use the notion of static factor, which is a special subvector of the latent vector i.e. those parts of output vector remaining after removal of contaminating additive noise in the measurement. Since the model associated with the static factor is periodic in the output parameters, we use the well-known technique of blocking to obtain a blocked linear time-invariant system associated with this model. It is illustrated that this blocked system is generically zero-free. Then we use the spectral factorization technique to obtain the parameter matrices associated with the blocked system. These parameter matrices can be obtained by a finite number of rational calculations from the spectral matrix due to the generic zero-freeness of all spectral matrices. Finally, we use the parameter matrices associated with the blocked system to obtain the parameter matrices associated with the static factor and ultimately those of the original underlying unblocked system.

Output Feedback Receding Horizon Control for Spatiotemporal Dynamic Systems
Tomoaki Hashimoto, Yu Takiguchi, Toshiyuki Ohtsuka
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Receding horizon control problem is investigated here for a generalized class of spatiotemporal dynamic systems. Receding horizon controllers often assume that all state variables are exactly known. However, it is usual that the state variables of systems are measured through outputs, hence, only limited parts of them can be used directly. Moreover, the output signals may be disturbed by process and sensor noises. In this study, we develop a design method of output feedback receding horizon control for a generalized class of spatiotemporal dynamic systems. We apply the contraction mapping method and unscented Kalman filter for solving the optimization and estimation problems, respectively. The effectiveness of the proposed method is verified by numerical simulations.

A Sub-principal Component of Fault Detection (PCFD) Modeling Method and Its Application to Online Fault Diagnosis
Chunhui Zhao, Li Wenqing, Youxian Sun
Zhejiang University, China

A sub-principal component of fault detection (PCFD) modeling method is proposed for online fault diagnosis for multiphase batch processes. Without the requirement of priori process knowledge, an automatic phase division algorithm is proposed to separate the abnormal batch process into multiple phases by capturing the changes of fault deviations throughout the batch. The similar fault characteristics are grouped into the same phase while different fault characteristics are classified into different phases. PCFD algorithm is then used to decompose the fault deviations relative to normal in different phases. Phase-representative fault diagnosis model is developed to capture the similar fault characteristics within the same phase and multiphase sub-phase models across different phases. Critical-to-diagnosis fault phases are defined and identified which have significant contributions to online fault diagnosis. Based on the identified phase nature and fault diagnosis relationships, an online fault diagnosis strategy is developed to isolate the possible abnormality cause real-time. The applications of the proposed scheme to a typical multiphase batch process, injection molding, show that the proposed analysis and fault diagnosis are not only effective but are also able to enhance fault process understanding and identify specific periods for fault diagnosis in time.

Stabilization of Uncertain Discrete Time-Delayed Systems via Delta Operator Approach
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This paper investigates the robust stabilization of uncertain time-delayed systems via delta operator approach. By introducing model transportation, the linear delta operator system with time-varying delays is reformulated into an interconnected system for which the uncertainties can become easy to deal with. Based on a two-term approximation and scaled small gain theorem, a new delay-dependent sufficient condition of state feed-back stabilization for an uncertain delta operator time-delayed system is established by using a novel Lyapunov-Krasovskii functional. The condition obtained can unify some previously suggested relevant methods seen in literature for achieving asymptotic stabilization of both continuous and discrete systems into the delta operator framework. Numerical examples presented explicitly demonstrate the advantages and effectiveness of the proposed method.
Consensus over Directed Graph: Output Feedback and Topological Constraints

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Abstract—In this paper, we study the consensus problem for discrete-time multi-agent systems over an directed, fixed network communication graph. A distributed dynamic output feedback control protocol is employed. Drawing upon concepts and techniques from robust control, notably those concerning gain-phase margin optimization and analytic interpolation, we derive explicit, closed-form conditions for general linear agents to achieve consensus. Our results display explicit dependence of the consensus condition on the agent’s unstable and non-minimum phase dynamics and agent’s relative degree imposed on key indicators of an directed graph.

Minimizing the memory of a system

Dominikus Noll, Ngoc Minh Dao
University of Toulouse, France

Consider a stable linear time-invariant system G(x) with tunable parameters x, which maps inputs w in \(L^2\) to outputs z in \(L^2\). Our goal is to find a choice of the tunable parameters \(x^*\) which avoids undesirable responses of the system to past excitations known as system ringing. We address this problem by minimizing the Hankel norm \(||G(x)||_{H_2}\) of G(x), which quantifies the influence of past inputs on future outputs.

A Finite-time Generalized H\(_2\) Gain Measure and Its Performance Criterion

Fenghua He, Wang Long, Jiawei Wang, Yu Yao, Denggao Ji, Weishan Chen
Harbin Institute of Technology, China

In this paper, we consider the performance measure problem of a linear time-varying system with non-zero initials and bounded external disturbance in a finite-time horizon. We propose a finite-time generalized \(SH_{25}\) gain which is defined as a ratio of the maximal penalty output and the sum of the energy of the exogenous input and nonzero initial conditions in a finite time interval. The finite-time generalized \(SH_{25}\) gain can be used as a performance metric of such a class of systems in the worst-case which are not required to be stable and with zero initials. We proved several properties of the proposed finite-time generalized \(SH_{25}\) gain and its performance criterion is also proved. The computation of the finite-time generalized \(SH_{25}\) gain is then treated. We also provide an application and simulation results of the proposed finite-time generalized \(SH_{25}\) gain measure.

Static LPV Feedforward Controller Synthesis for Linear Parameter Varying Systems

Yusuf Altun, Kayhan Gulez, Tarik Veli Mumcu
Yildiz Technical University, Turkey

This paper proposes a new static feedforward controller synthesis for linear parameter varying (LPV) systems. In this approach, the matrices of system are dependent on measurable parameters which have bounded variations. The proposed controller design is based on H infinity controller design and is formulated in terms of Linear Matrix Inequalities (LMIs). Parameter-dependent Lyapunov function is used for the synthesis where the robust stability is guaranteed for all varying parameters during the control. This controller is used by combining on the feedback controller in two degrees of freedom (2-DOF) control system structure. It is assumed that the feedback controller in the generalized system is previously designed in the structure. Afterwards the feedforward controller is designed by imposing on the feedback controller. The controller design can be used for decreasing the reference tracking error or the disturbance attenuation. A numerical example is given to provide the applicability of the controller for decreasing the reference tracking error.
system operates under an autonomous navigation state throughout the calibration process, relaxing the requirement of switching the operating mode of the system. Third, the gyros are assumed to have a rotational limit of ±60° on outer gimbal and inner gimbal axes. A modified dynamic model is established to adapt to the changes mentioned previously. The observation model is based on the output model of accelerometers. Then the EKF is applied to estimate the coefficients since the model is nonlinear. The simulation results substantiate the effectiveness of the method.

Rapid Alignment Method of INS with Large Initial Azimuth Error under Uncertain Flexure Disturbances
Xin Liu, Bo Wang, Zhihong Deng, Shunting Wang, Hua Liu
Beijing Institute of Technology
A new nonlinear initial alignment method was proposed for the rapid alignment of the ship-borne weapon INS with large initial azimuth attitude error under uncertain flexure deformation disturbances. Considering the deformation flexure of certain axis has the severest affection to the angular rate measurement, velocity and partial angular rate were used as the measurements in this method, in which the pitch rate is subtracted from the angular rate measurement. Simulation results show that comparing with the conventional solution, which compensates the flexure deformation by augmenting its model into the alignment filter, the proposed alignment method can accomplish the transfer alignment of a mooring ship’s weapon INS with large heading error rapidly and accurately, and it is more reliable in the situation of flexure deformation uncertainty.

Modeling and Analysis of Stray Light Impact on Coarse Sun Sensor
Xiaopeng Liu, Zhenyan Zhao, Yuanqing Xia, Xi-Ming Sun
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The coarse sun sensor (CSS) is an analog sun vector detector consisting of multiple optical battery cells. It is small, light, simple-structured, and of wide field of view (FOV). However, its performance could be easily affected by the stray light. In this article, modeling of interference of the stray light in CSS on a satellite Z panel is formulated. A Model of interference of the stray light from the satellite surface is built, and the interference value is calculated. The analysis result shows that the interference from the satellite wrapped coverings is most and reaches a maximum value of -1.2033. Further suggestions are given and an analysis approach for practical engineering applications is then provided.

Moving Base Disturbance Suppression Method of Rotary INS Based on Rotation Angular Rate
Yuan Zhou, Zhihong Deng, Bo Wang, Mengyin Fu, Shunting Wang, Xuan Xiao
Beijing Institute of Technology, China
Rotation modulation is an effective method to suppress the errors of the inertial navigation system (INS). However, when the carrier is in angular motion status, the effect of error suppression will be influenced. The influence is obvious especially when the carrier’s heading angle changes largely. A parameter named moving-base rotation modulation (MRM) coefficient is proposed, which is used to analyze the relationship between the angular rate of rotation modulation and the effect of rotation modulation. According to the analysis result, when the rotary INS works in the rotation angular rate range with a smaller MRM coefficient, the disturbance to error compensation from the carrier’s motion will be decreased, so that the precision of INS will be improved. This method is simple to realize and without extra system complexity, which is practical in engineering application.

On Initial Alignment Methods for Manned Lunar Ascent Module
Qingzhe Wang, Ping Wang, Linli Guo, Zhihong Deng
1Beijing Institute of Technology, China; 2China Academy of Space Technology, China
Since the orbit injection accuracy of the Lunar Lander Ascent Module (LLAM) is largely determined by the accuracy of inertial navigation system (INS), an accurate alignment of INS is crucial and needed to be implemented before LLAM leaves the lunar surface. Lunar alignment differs from ground alignment in low rotational rate and gravity. To provide satisfying results, new alignment methods should be adopted. In this paper, a novel technique named star tracker aided alignment is proposed which combines inertial and stellar observations using a Kalman filter algorithm. Performance of the approach is compared with that of traditional self-alignment method using simulation data. The results show that the star tracker aided alignment can effectively estimate the misalignment angels. Besides, the gyro accuracy deeply affects the heading accuracy of self-alignment method, while having no influence on star tracker aided alignment.

Implementation of Micro-inertial Measurement/GPS Combinatorial Attitude Measurement System
Xiaorong Shen, Yueming Wang, Rongsheng Dong
Beijing University of Aeronautics and Astronautics, China
The attitude information is one of the most importance for navigation or stabilization control. In this paper, a low cost and robust micro inertial measurement/GPS combinatorial attitude measurement system is implemented. The attitude is obtained with two-antenna GPS configuration combined with micro-inertial measurement unit. Based on the analysis of the fusion algorithm for attitude estimation, the filter model is constructed with error multiplicative quaternion. Furthermore, the UD decomposition is adopted to suppress the filter divergence. The experiment result shows that the design satisfies the precision requirements for unmanned aerial vehicles or other tactical applications.
Hyperstability Analysis of Switched Systems Subject to Integral Popovian Constraints

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This paper studies the asymptotic hyperstability of switched time-varying dynamic systems. The system is subject to switching actions among linear time-invariant parameterizations in the feed-forward loop for any feedback regulator controller. Moreover, such controllers can be also subject to switching through time while being within a class which satisfies a Popov's-type integral inequality. Asymptotic hyperstability is proven to be achievable under very generic switching laws if (i) at least one of the feed-forward parameterization possesses a strictly positive real transfer function, (ii) a minimum residence time interval is respected for each activation time interval of such a parameterization and (iii) a maximum allowable residence time interval is simultaneously maintained for all active parameterization which are not positive real, if any.

Calculation of the least $\mathcal{L}_1$ measure for switched linear systems via similarity transformation

Meili Lin, Zhendong Sun

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A strategy of similarity transformation is proposed to calculate the least $\mathcal{L}_1$ measure for continuous-time switched linear systems. The similarity transformation we performed on matrix $A$ is $PAP^\top$, where the similarity transformation matrix $P$ is a row operator multiplying a row of matrix $A$ by a nonzero constant. A sequence of minimum of matrix set measure corresponding to a series of transformations is obtained. Furthermore, the sequence is convergent to a constant which can be used to estimate the largest divergence rate. These transformations are easily applicable because of their simple forms. A numerical simulation shows the effectiveness of the proposed method.

Neural Aided Discrete PID active Controller for Non-Linear Hysteretic Base-Isolation building

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The combination of isolation system and active control devices has been increasingly considered in the structural control community to design an efficient smart hybrid base-isolation system for seismic protection. In this paper, a control scheme based on a combination of discrete PID controller and discrete direct adaptive neural controller is proposed for the active control of a nonlinear base isolated building to reduce superstructure responses and base drifts under near-fault earthquake excitations. Even though the PID controller is a traditional and widely used in many control applications, the performance of PID controller is not satisfactory in time varying and nonlinear systems. But the efficiency of its performance can be enhanced by combining the PID controller along with neural controller. The neural controller is constructed based on a single hidden layer feed forward network and the parameters of the network are modified using extreme learning machine (ELM) - like algorithm. To ensure the stability of the system, unlike original ELM algorithm, Lyapunov update law is used to update the output parameters of the network. This approach is validated by simulating a non-linear three dimensional benchmark base-isolated structure with time history records of three near-fault earthquakes. The performance of the proposed control scheme is measured in terms of a comprehensive set of performance indices. The results show that the proposed neural aided discrete PID active controller is more effective in reducing the superstructure acceleration, inter-storey drifts and base displacement by giving an active feedback control force to the base-isolated structure.

Passivity-based Finite-time Attitude Control Problem

Shuochen Liu, Junyong Sun, Zhiyong Geng

Peking University, China

In this paper the passivity-based finite-time attitude control problem of a rigid spacecraft is addressed. Firstly, for a certain class of nonlinear passive system we derive different control laws according to different choices of storage functions. Based on this result, combining the sliding mode control method, we propose a passivity-based finite-time controller for a rigid spacecraft. Performances of the proposed controllers are illustrated by simulation.
Virtual constraints for the underactuated walking design: comparison of two approaches
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The virtual constraints method is used here to design and control the walking-like trajectory of the 4-link having 4 degrees of freedom: stance angle, 2 knees angles and 1 hip angle and 3 actuators only as the stance leg angle is not actuated. Two different approaches are compared. First, the well-known approach consists in setting virtual constraints as the dependencies of knees and hip angles on the stance leg angle. Therefore there are 3 virtual constraints enforced by all 3 available inputs and reducing thereby overall 4 degrees of freedom to a single degree of freedom unactuated system. Selecting suitable constraints functions, various walking-like trajectories can be designed. Secondly, this three constraints approach is compared with the alternative one developed very recently. Here, only two constraints are imposed being dependencies of knees angles on the hip angle thereby reducing the 4-link to 2 degrees of freedom system with a single actuator at the hip angle. Such a system may be naturally called as the generalized Acrobot. Comparison of both approaches is performed by numerical simulation using 4-link mathematical model of real laboratory equipment. In the future, the most suitable method would be selected for the real implementation, in particular, based on the current comparative study.
Robust Adaptive Attitude Synchronization of Rigid Body Networks with Unknown Inertias
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University of Waterloo, Canada

In this paper we consider the attitude synchronization task for rigid body networks. The configurations of such systems evolve on SO(3), which is a nonlinear manifold and needs a special treatment for fulfilling this task. We propose two robust adaptive algorithms to handle the effects of unmodeled dynamics and unknown inertia matrices of agents. Our first approach is based on sigma modification method which “trap” the trajectories of the system in to a small neighborhood around the origin. In the second algorithm, the effects of external disturbances are removed by using a discontinuous function. We use the Lyapunov Theory to prove the main results of this paper. Simulation results show the effectiveness of our proposed methods.

Neural – Adaptive Control for Electro Hydraulic Servo System
Zohreh Alzahra Sanai Dashti1, Milad Gholami2, Mahdi Aliyari Shoorehdeli2, Mohammad Teshnehlab2
1Islamic Azad University, Iran; 2K.N. Toosi University of Technology, Iran

In this study Neural Adaptive is used for velocity control and identification of an electro hydraulic servo system (EHSS) in the presence of flow nonlinearities, internal friction and noise. It has been found that this technique can be successfully used to stabilize any chosen operating point of the system with noise and without noise. All derived results are validated by computer simulation of a nonlinear mathematical model of the system. The controllers introduced have vast range to control the system. We compare Neural Adaptive controller results with feedbacks linearization, back stepping and PID controller.

A Combined Backstepping and Wavelet Neural Network Control Approach for Mechanical System
Chiung-Chou Liao1, Chi-Hsiung Chen2, Ya-Fu Peng2, Sung-Chi Wu2
1Chien Hsin University of Science and Technology, Taiwan; 2Chung-Shan Institute of Science and Technology, Taiwan

A combined backstepping and wavelet neural network control approach for mechanical system is proposed in this paper. The proposed control approach comprises a neural controller and a robust compensator. The neural controller using a wavelet neural network (WNN) is the main controller based on backstepping method; and the parameters of WNN are on-line tune by adaptation laws from the Lyapunov stability theorem. The robust compensator is designed to dispel the approximation error, so the asymptotic stability of the system can be guaranteed. Finally, a mass-spring-damper system is performed to verify the effectiveness of the proposed control scheme.

A New Iterative Online Dynamic Identification Method of Robots from only Force/Torque Data
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1Institute /Research Institute of Communications and Cybernetics of Nantes, France; 2ONERA (The French Aerospace Lab), France; 3L’UNAM (L’University Nantes Angers le Mans), France

This paper deals with a new iterative online dynamic identification method of robot. The robot is closed-loop controlled with a computed torque control (CTC) law that linearizes and decouples the non-linear and coupled dynamics of the robot. Usually, the parameters of the Inverse Dynamic Model (IDM), which calculates the CTC, are identified with an off-line identification method which uses the Inverse Dynamic Identification Model (IDIM) to calculate the joint force/torque as a linear relation in the dynamic parameters. This allows using linear least-squares techniques to estimate the parameters that minimize the 2-norm error between the actual joint force/torque and the calculated joint force/torque (IDIM-LS method). This method requires well tuned bandwidth filtering of the joint position to estimate the joint velocity and acceleration and cannot take into account variations of the parameters (friction, payload) in CTC. The new method overcomes these 2 drawbacks. The IDIM-LS solution is periodically calculated over a moving time window to update the IDM of the CTC, and the IDIM is calculated with the noise-free data of the trajectory generator, which avoids using the noisy derivatives of the actual joint position. This method called IDIM-ILIC, works like an Iterative Learning Identification and Control procedure. An experimental setup on a prismatic joint validates the procedure with stationary parameters and with a variation of the payload.

A New Technique in Multi-Model Adaptive Control: Sequential Parameter Discrimination and Hybrid Parameter Vector
Ahmet Cezayirli
Forevo Digital Design Ltd., Turkey

We propose a new methodology in order to provide faster convergence in adaptive control of a class of nonlinear plants. Currently, each model in a multi-model adaptive system is evaluated as a whole, using a cost function derived from estimation errors. Therefore the number of fixed models required for improvement in transient response becomes quite
large, for the plants having several unknown parameters. The proposed scheme removes this difficulty by considering each parameter sequentially and individually; and provides better convergence as compared to classical multi-model adaptive systems by using an assumption that a decrease in any element of the parameter error vector results in decrease in the state estimation error and vice-versa.

Reference Governor for Output Smoothing of Renewable Energy Generation
Yutaka Tsubota1, Genki Baba2, Kenko Uchida2, Toru Jintsugawa2, Yosuke Nakanishi2
1Waseda University, Japan; 2Fuji Electric Co., Japan
Output smoothing using storage facilities for wind turbine generators has been realized typically by means of a first order system, as a low pass filter, together with compensators for keeping a level of energy storage and several limiters for energy flows; however, it is not easy to achieve an appropriate combination of the filter, the compensators and the limiters, for a desired performance of the output smoothing. To overcome this difficulty, we propose a new scheme of the output smoothing, which generates, by solving a Model Predictive Control (MPC) problem, an optimal reference signal for storage facilities so that the output smoothing is achieved and the constraints on the storage level and the energy flows are satisfied; in this scheme, trade-offs among smoothing performance and constraint fulfillment levels can be designed by selecting weighting parameters in the performance index. We perform numerical simulations, and discuss usability of the proposed scheme by comparing it with the existing output smoothing methods using fixed time-constant filter.

Maximum Power Point Tracking of Directly Driven PV-RO Systems
Khaled Alshehri, Moustafa Elshafei, Anwar Khalil Sheikh
King Fahd University of Petroleum and Minerals, Saudi Arabia
In this paper, a new simple algorithm is proposed for tracking the maximum power point (MPP) in photovoltaic-driven reverse osmosis systems by manipulating the position of the valve on the brine side of the reverse osmosis system. The mathematical model is presented and simulated to illustrate the new approach. A simple algorithm for adjusting the valve position for MPP tracking is provided, and the performance of system is demonstrated under varying solar radiation. The technique is particularly suitable for remote desert areas as in Saudi Arabia and African Sahara region, where clear sky is available almost throughout the year.

Graph Partitioning of Power Network for Emergency Voltage Control
Hasan Mehrjerdi1, Serge Lefebvre3, Dalal Asber2, Maarouf Saad2
1Hydro-Quebec’s Research Institute, Canada; 2Quebec University, Canada
This paper presents an electrical network graph partitioning technique that divides a power network into zones. The idea of partitioning is to prevent the propagation of disturbances between zones and avoid cascading events in response to disturbances. Identifying coherent groups of buses in power electrical networks is crucial to implement efficient control strategies based on partitioning techniques. Furthermore, the coherent buses can be used for model reduction of complex power systems. Graph theory has an excellent capability to simplify large connoted networks such as the case with large power networks. In this paper, graph partitioning algorithm is applied to electrical networks including IEEE 39-bus and IEEE 118-bus. Graphs with and without weights are considered to investigate and compare the results of using graph partition algorithm. Weights in a graph power system can be real, reactive or apparent power transferred between buses. Finally, disturbances are intentionally inserted on the loads to verify the performance of partitioned power network to violation. The results show the performance and ability of graph partitioning when used in conjunction with a large power network.

Smart Pitch Control Strategy for Doubly Fed Wind Generation System Using Adaptive Neural Networks
Syed Ahmed Raza, Nouredinne Harid
Prince Mohammad Bin Fahd University, Saudi Arabia
This paper presents a study on smart pitch control strategy for a variable speed doubly-fed wind generation system. Non-linear as well as linearized dynamic models of the wind system pitch controller and the doubly fed induction generator including the drive train are developed. A PI controller is employed to generate the appropriate pitch angle for varying wind speed conditions using an adaptive artificial neural network (ANN) and a simple neural network (NN) to produce PI gain settings for various wind speed conditions. The training data, on the other hand, was generated through differential evolution (DE). Simulation studies show that the DE based adaptive ANN can generate the appropriate control to deliver the wind power to the generator efficiently with minimum transients.
Multivariable Input-Output Linearization Sliding Mode Control of DFIG Based Wind Energy Conversion System

Akbar Tohid, Ali Shamshadinlou, Ali Khaki Sedigh
K.N.Toosi University of Technology, Iran

In this paper, obtaining of maximum active and reactive output power for wind turbines equipped with a double fed induction generator using stator-flux-oriented vector control based on novel multivariable input output linearization sliding mode control presented. The main control problem is the estimation of maximum power operating points of wind turbine under stochastic wind velocity profiles and tracking them using conventional offline and innovative adaptive online method. In this control strategy the wind speed and consequent aerodynamics torque is considered as the disturbance. Results under different operating conditions show the superior performance of the proposed online input-output linearization sliding mode technique.

On-line Schedule Model for Reusable Equipment Maintenance and Support Resource in Wartime

Quan Jia, Yaoyu Li
National University of Defense Technology University, China

Based on the discussion of reusable equipment maintenance and support resource in wartime, an on-line schedule model is proposed. Firstly, this paper analyzes the difference of the scheduling process between reusable resource and consumption resource in wartime. Secondly, the model takes the following issues into account: the priority of fault node, the acceptable waiting time of fault node, the different Mean Time Between Failures (MTBF) of fault node, the centralized control and distributed control. Furthermore, with the temporal and priority constraints, the on-line scheduling process returns the best solution in real time by using the Genetic Algorithm. An on-line simulation system based on System Effectiveness Analysis Simulation (SEAS) is designed to confirm that, comparing with the FIFO model and minimum distance model, the on-line schedule model can reduce the mean-latency-time of the fault node effectively in war time.

Developing a New Image Scanning Method Using Atomic Force Microscopy

Habibullah Habibullah, Hemanshu Pota, Ian Petersen
University of New South Wales, Australia

In this paper, we present a spiral scanning method using an atomic force microscope (AFM). A spiral motion is generated by applying slowly varying amplitude sine wave in the X-axis and cosine wave in the Y-axis of the piezoelectric tube (PZT) scanner of the AFM. An LQG controller also designed for damping the resonant mode of the PZT scanner for the lateral positioning of the AFM scanner stage. In this control design, an internal model of the reference sinusoidal signal is introduced with the plant model and an integrator with the system error is introduced. A vibration compensator is also designed and included in the feedback loop with the plant to suppress the vibration of the PZT at the resonant frequency. Experimental results demonstrate the effectiveness of the proposed scheme.

Adaptive Optimal Control Algorithm for Maturing Energy Management Strategy in Fuel-Cell/Li-ion-Capacitor Hybrid Electric Vehicles

Wei-Song Lin, Yu-Chun Huang, Chen-Hong Zheng, Chao-Ming Lee
National Taiwan University, Taiwan

Energy management in a fuel cell/Li-ion capacitor hybrid electric vehicle needs to determine appropriate power split between the load and the distinct power sources in order to minimize fuel consumption and power fluctuations in the fuel cell system while supplying adequate power to the load, and the state-of-charge of the Li-ion capacitor maintained at the permissible levels. This paper formulates this case as a problem of fuel minimization subject to mixed equality and inequality constraints imposed by the dynamics and operational limitations of the fuel cell and Li-ion capacitor. Then the adaptive optimal control algorithm is proposed to automatically draw out the best energy management strategy via reinforcement learning and sequential optimization in standard driving cycles. The results of testing the algorithm in a fuel cell/Li-ion capacitor hybrid electric sedan verifies the efficacy of the proposed design in energy saving.

On Sampled-Data Extremum Seeking Control via Stochastic Approximation Methods

Sei Zhen Khong, Ying Tan, Dragan Nesic, Chris Manzie
University of Melbourne, Australia

This note establishes a link between stochastic approximation and extremum seeking of dynamical nonlinear systems. In particular, it is shown that by applying classes of stochastic approximation methods to dynamical systems via periodic sampled-data control, convergence analysis can be performed using standard tools in stochastic approximation. A tuning parameter within this framework is the period of the synchronized sampler and hold device, which is also the waiting time during which the system dynamics settle to within a controllable neighbourhood of the steady-state input-output
behaviour. Semi-global convergence with probability one is demonstrated for three basic classes of stochastic approximation methods: finite-difference, random directions, and simultaneous perturbation. The tradeoff between the speed of convergence and accuracy is also discussed within the context of asymptotic normality of the outputs of these optimisation algorithms.

On the Effect of Adding Frequency-Response-Constrained Input Channels on the Achievable Performance of Discrete-Time Control Systems

Ignacio Latorre, Eduardo Silva, E. Salgado Mario
Universidad Tecnica Federico Santa Maria, Chile

This paper deals with the effect on the control performance, of adding frequency-response-constrained control channels to a stable, discrete-time and linear time-invariant MIMO plant. We focus on the control tracking problem with step references, in which a 2-norm based performance index is considered. In order to introduce the frequency-response limitations of the additional channels, we assume that the constraint is on the energy of the stationary deviations of the additional input signals filtered by a previously selected filter. The main result of this work is a closed form expression that quantifies the benefits on the control performance of square MIMO plants when adding input channels with those limitations.

Experience-Based Identification and Model Predictive Control for A Methanol Recovery Distillation Column

Bingqiang Huang, Yong Gu, Hongye Su
Zhejiang University, China

In process industries, the plant testing method, which is used to obtain a model for the design of a MPC controller, is a kind of commonly used system identification method. However, this method has the disadvantages of time-consuming and production disruption. For this reason, in this paper, the bottom stage temperature control system of a methanol recovery distillation column is taken as the research object, and the model predictive effects based on step tests and experiences from operators are simulated and compared. Finally, a MPC controller based on an experience model is designed and put into operation. The actual plant application shows that the MPC controller could effectively improve the stability of the bottom stage temperature.

Stabilization of Linear Discrete-time Periodic Systems with Uncertain Period

Jianbo Lu, Dewei Li, Yugeng Xi
Shanghai Jiaotong University, China

In this paper, stabilization problem for constrained linear discrete-time periodic systems with uncertain period is investigated, where the uncertain period is caused by the probabilistic transitions of some mode to the next mode or to itself. Results are given for three cases, robust stabilization, stochastic stabilization by utilizing the transition probabilities, and MPC design. All these designs are based on the use of mode-dependent state feedback control law. Conditions guaranteeing the close-loop stability and satisfaction of constraints on inputs and states are given in terms of LMIs. Finally a numerical example is given to verify the efficiency of the developed results.

Improved Future Model Prediction and Robust MPC Design for LPV Systems with Bounded Rates of Parameter Variations

Pengyuan Zheng, Dewei Li, Yugeng Xi
Shanghai Jiaotong University, China

For linear parameter varying (LPV) systems with bounded rates of parameter variations, the prediction of future system dynamics is an important issue for the control performance of robust model predictive control (RMPC). A future model prediction method is proposed. By introducing more freedom, the proposed method can predict the future system dynamics more precisely than the existing approaches, which improves the control performance of RMPC.

Feasible Distributed MPC Scheme for Network Systems Based on an Inexact Dual Gradient Method

Ion Necoara, Andrei Valentin Nedelc, Dragos Nicolae Clipici
Politehnica University of Bucharest, Romania

In this paper we propose an inexact dual gradient method for solving large-scale smooth convex optimization problems. For the proposed algorithm we provide estimates on primal and dual suboptimality and primal infeasibility. We solve the inner problems by means of a parallel coordinate descent method with linear convergence rate. We adapt our method using constraint tightening and obtain a distributed MPC strategy for network systems which guarantees feasibility.
Data-Based Modeling of Vehicle Collision by LPV-ARMAX Model Approach
Qiugang Lu, Witold Pawlus, Hamid Reza Karimi, Kjell Gunnar Robbersmyr
University of Agder, Norway
Vehicle crash are considered to be events with high complexity from the mathematical points of view. The high experiment cost and huge time-consumption make the establishment of a mathematical model of vehicle crash which can simplify the analysis process in great demand. In this work, we present the application of LPV-ARMAX model to simulate the car-to-pole collision with different initial impact velocities. The parameters of the LPV-ARMAX are assumed to be functions of the initial impact velocities. Instead of establishing a set of LTI models for vehicle crashes with various impact velocities, the LPV-ARMAX model is comparatively simple and applicable to predict the responses of new collision situations different from those used for identification. The comparison between the predicted response and the real test data is conducted, which shows the high fidelity of the LPV-ARMAX model.

Preliminary Feasibility Studies of Real-Time Substructuring Control Strategies
Chih Ying Chen, Jiaying Tu, Youchuhan Chen, Weide Xiao
National Tsing Hua University, Taiwan
Dynamic substructuring is a hybrid testing strategy, which enables full-size, critical components of an entire engineering system to be physically tested, whilst the remaining parts are simulated numerically. Successful tests require a robust controller to compensate for unwanted dynamics introduced by supplemental actuators within the physical substructure and to achieve synchronized responses of the numerical and physical parts in real-time. The aim of this feasibility study tries to identify the relative strength and weakness of three types of substructuring control strategy in literature, including (i) emulated-system-based (ii) numerical-substructure-based, and (iii) output-based controllers. The first two controllers are synthesized via conventional dynamics-based approaches, while the third using forward-prediction and curve-fitting concepts is classified as a geometry-based strategy. A practical substructuring example using a shaking-table system is presented for control comparisons. In the presence of uncertainties with the actuators or specimens, simulation studies show that these controllers exhibit distinct robustness in different cases.

Design of Optimal Disturbance Cancellation Controllers for Sinusoidal Output Disturbances via Loop Transfer Recovery
Tadashi Ishihara, HaiJiao Guo
1Fukushima University, Japan; 2Tohoku Gakuin University, Japan
This paper discusses an application of the classical loop transfer recovery technique to the design of the optimal disturbance cancellation controller for the sinusoidal output disturbance with known frequency. The optimal output feedback controller is constructed based on the separation principle. The target of the design is chosen as the estimation error dynamics including the internal model for the sinusoidal disturbance. It is shown that the target feedback property can be recovered by using the weighting parameter in the performance index. A numerical example is presented to illustrate the effectiveness of the proposed design.

Repetitive Control of An Artificial Muscle Actuator
Mehmet Itik
Karadeniz Technical University, Turkey
Electroactive polymers also known as ‘Artificial Muscles’ are promising materials for actuation purposes in diverse application areas such as robotics, aerospace and biomedical systems. This paper investigates the dynamics of a polypyrrole conducting electroactive polymer actuator which is desired to track repeating reference commands. We propose a plugin repetitive controller to improve the tracking performance of a conducting polymer actuator. The repetitive controller is implemented in cascade with a PI (proportional-integral) controller. The response of the system with repetitive controller is then compared to that of obtained by the implementation of the stand-alone PI controller. The experimental results show that the repetitive controller gives superior results compared to the PI controller and improves the tracking performance significantly.

On the Stabilization of An Irrigation Channel with a Cascade of 2 Pools: A Linearized Case
Dongxia Zhao, Jun-Min Wang
Beijing Institute of Technology, China
This paper deals with the exponential stability of the linearized Saint-Venant equations. The stability analysis relies on the spectral analysis method, it is shown that the closed loop system has a set of generalized eigenfunctions, which form a Riesz basis for the state space, and hence the spectrum-determined growth condition is deduced.
The Parameterization of All Stabilizing Two-Degree-of-Freedom Simple Multi-Period Repetitive Controllers with Specified Frequency Characteristic

Tatsuya Sakunushi, Yun Zhao, Jie Hu, Satoshi Tohnai, Kou Yamada
Gunma University, Japan

The simple multi-period repetitive control system proposed by Yamada and Takenaga is a type of servomechanism for periodic reference inputs. This system follows a periodic reference input with a small steady-state error, even if there is periodic disturbance or uncertainty in the plant. In addition, simple multi-period repetitive control systems ensure that transfer functions from the periodic reference input to the output and from the disturbance to the output have finite numbers of poles. Yamada and Takenaga clarified the parameterization of all stabilizing simple multi-period repetitive controllers. Recently, Yamada et al. proposed the parameterization of all stabilizing two-degree-of-freedom (TDOF) simple multi-period repetitive controllers that can specify the input-output characteristic and the disturbance attenuation characteristic separately. However, when using the method of Yamada et al., it is complex to specify the low-pass filter in the internal model for the periodic reference input that specifies the frequency characteristic. This paper expands the result by Yamada et al. and proposes the parameterization of all stabilizing TDOF simple multi-period repetitive controllers with specified frequency characteristic such that the low-pass filter can be specified beforehand.

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Optimized State Feedback Regulation of 3DOF Helicopter System via Extremum Seeking

Rini Akmeiawati, Safanah Raafat
1 International Islamic University Malaysia, Malaysia; 2 University of Technology UOT, Iraq

In this paper, an optimized state feedback regulation of a 3 degree of freedom (DOF) helicopter is designed via extremum seeking (ES) technique. Multi-parameter ES is applied to optimize the tracking performance via tuning State Vector Feedback with Integration of the Control Error (SVFB-ICE). Discrete multivariable version of ES is developed to minimize a cost function that measures the performance of the controller. The cost function is a function of the error between the actual and desired axis positions. The controller parameters are updated online as the optimization takes place. This method significantly decreases the time in obtaining optimal controller parameters. Simulations were conducted for the online optimization under both fixed and varying operating conditions. The results demonstrate the usefulness of using ES for preserving the maximum attainable performance.

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Constant Velocity Control of a Miniature Pantograph with Image Based Trajectory Generation

Eray A. Baran, Edin Golubovic, Tarik E. Kurt, Asif Sabanovic
Sabanci University, Turkey

This paper presents a methodological approach for the practical realization of high precision laser micromachining over shapes of arbitrary geometry. The scheme presented throughout the paper includes an easy-to-use way of reference generation via image processing for shapes that is mathematically difficult to represent. The necessary constraint of tracking the constant reference tangential velocity for high precision laser production is enabled via the so called spline polynomial interpolation method. The description of algorithmic steps for the acquisition of reference cartesian trajectory from an image is followed by the presentation of spline method and the controller used for the realization. The proposed approach is tested in experiments and the validity of the methodology is verified for practical implementation.

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Feasible Approach to Control the Operation of Implantable Rotary Blood Pumps for Heart Failure Patients

Mohsen Bakouri, Andrey Savkin, Abdul-Hakeem AlOmari, Robert Salamonsen, Eimly Lim, Nigel Lovell
1 University of New South Wales, Australia; 2 University of Dammam, Saudi Arabia; 3 Monash University, Australia; 4 The University of Malaya, Malaysia

In order to assess left ventricular support in heart failure patients, a lumped parameter model of a rotary blood pump and the cardiovascular system was used to investigate different control strategies. In this paper, a sensor-less control strategy for a left ventricular assist device (LVAD) based on pulsatile flow estimation has been presented, which referred to the crucial issue in the usefulness of LVADs is how to control the operation of the pump rotational speed to cater for cardiovascular system perturbations and changing metabolic demand for heart failure patients. A tracking control algorithm based on a robust sliding mode technique was developed to track the error difference between the reference pump flow and estimated mean pulsatile flow. A lumped parameter model of cardiovascular system in combination with the stable dynamical model of pulsatile flow estimation was used to evaluate the controller. The control algorithm was tested using constant and sinusoidal reference pump flow inputs under healthy and heart failure conditions. Tracking control was illustrated in the presence of modeling uncertainty and disturbance. Simulation results demonstrated that the control algorithm was able to track the reference input with minimal error in the presence of model uncertainty.
State of Charge Management for Plug in Hybrid Electric Vehicles with Uncertain Distance to Recharge

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The state of charge management of plug in hybrid vehicles differs from their non-plug in counterparts through the utilisation of a charge depleting mode of operation. Several studies have shown that a blended mode of charge depletion holds fuel economy advantages over a charge depletion and charge sustaining combination, however these approaches assume knowledge of the total journey distance. Here, this assumption is relaxed and the state of charge trajectory recalculated online using a weaker assumption that only a probability distribution accumulated over past trips is available. The benefits relative to other potential strategies are assessed in terms of relative fuel consumption and tailpipe CO2 emissions.
A Decentralized Control Algorithm Based on the DC Power Flow Model for Avoiding Cascaded Failures in Power Networks
Saleh Al-Takrouni, Andrey V. Savkin, Vassilios G. Agelidis
The University of New South Wales, Australia
A distributed random algorithm for controlling electrical power flow after a failure in (or attack on) a power transmission grid is proposed. The aim is to minimize load shedding and to avoid a cascaded failure in the network. The DC power flow model is used to simulate the power flow in the network. The algorithm is based only on the information about the closest neighbours of each node. A mathematically rigorous proof of convergence with probability 1 of the proposed algorithm is provided.

Static Output Feedback Adaptive Integral Sliding Control for Interconnected Nonlinear Systems
Eshag Larbah, Ron Patton
University of Hull, UK
The problem of static output feedback decentralization of uncertain inter-connected systems is concerned with the goal of de-coupling Lipschitz non-linear systems into individual “decentralized” subsystems, satisfying stability and fault-tolerance objectives. This work proposes a strategy for decentralized control in which each subsystem uses a static output structure invoking an approach to separation principle recovery. The approach is based on Adaptive Integral Sliding Mode Control (AISMC) with careful consideration of both matched and unmatched uncertainties arising from inter-connections and disturbances. The proposed design strategy for the static output feedback and uncertainty de-coupling designs involves an LMI procedure to solve a non-convex problem. An example of 3 unstable inter-connected non-linear systems is used to illustrate the power of the approach.

Position Feedback Pinning Control for Nonlinear Multi-agent Systems
Ming-Can Fan¹, Zhiyong Chen², Hai-Tao Zhang³
¹Huazhong University of Science and Technology, China; ²University of Newcastle, Australia
This paper addresses a velocity consensus control problem for multi-agent systems in a complicated scenario where the agent velocities are not measurable and the agent dynamics are intrinsically nonlinear. It is proved that the proposed position feedback controller with sufficiently large but explicitly designed gains is able to deal with system nonlinearities when the region of attraction is semi-globally specified. The results are also verified in numerical simulation.

Setpoints Compensation in Industrial Processes via Multirate Output Feedback Control
Shen Yin¹, Fangzhou Liu¹, Huijun Gao¹, Jianbin Qiu¹, Tianyou Chai¹, Jialu Fan¹, Hamid Reza Karimi³
¹Harbin Institute of Technology, China; ²Northeastern University, China; ³University of Agder, Norway
This paper investigates the setpoints compensation for a class of complex industrial processes. Plants at the device layer are controlled by the local regulation controllers, and a multirate output feedback control approach for setpoint compensation is proposed such that the subsystems can reach the dynamically changed setpoints and the given economic objective can also be tracked via certain economic performance index (EPI). First, a sampled-data multivariable direct output feedback proportional integral (PI) controller is designed to regulate the performance of the subsystems. Second, the outputs and control inputs of the plants at the device layer are sampled at operation layer sampling time to form an EPI. Thus the multirate problem is solved by a lifting method. Third, static setpoints are generated by real time optimization (RTO) and the dynamic setpoints are calculated by the compensator according to the error between the EPI and objective at each operation layer step. Finally, a rougher flotation process model is employed to demonstrate the effectiveness of the proposed method.

Distributed Tracking for Networked Euler-Lagrange Systems Using Only Relative Position Measurements
Qingkai Yang, Hao Fang, Yutian Mao, Jie Huang, Jian Sun
Beijing Institute of Technology, China
In this paper, the problem of distributed coordinated tracking control for networked Euler-Lagrange systems using only relative position measurements is studied. Under the condition that only a subset of followers have access to the leader, sliding mode estimators are developed to estimate the states of the dynamic leader accurately in finite time. A set of distributed observers which only uses relative position information is designed to deal with the unavailability of the followers’ velocities. Using the observer outputs, distributed control laws are proposed such that the objective of tracking a dynamic leader under a spanning tree is achieved. The asymptotic stability of the proposed distributed observer-controller is proved through Lyapunov method. Numerical simulation results are also provided to show the effectiveness of the control laws.
**Necessary and Sufficient Condition of Consensus for Affine Multi-Agent Cooperative Systems under Time-Varying Directed Networks**

Jidong Jin\(^1,2\), Yufan Zheng\(^1,3\)
\(^1\)Shanghai University, China; \(^2\)Capital University of Economics and Business, China; \(^3\)The University of Melbourne, Australia

This work studies the necessary and sufficient condition for a class of affine multi-agent system under time varying directed network. A notion called adjoin graph of time-varying network, whose properties will be used as the criterion of system achieving consensus, is initiated. By a decomposition on adjoin graph of the time-varying directed network, the system may consist of several independent basic components and non-independent basic components of the system. Based on this composition and some assumptions on the system, we provided the necessity and sufficient condition for achieving consensus of systems. This work extends and modifies the results given in our previous paper.

25th June, Tuesday
14:00 - 16:00 at Malazgirt 1
TuB2 Advances in Nonlinear Control and Applications
Session Chair: Zongli Lin, University of Virginia, USA
Session Co-Chair: Zhong-Ping Jiang, Polytechnic Institute of New York University, USA

**Multistability of A Class of Biological Systems**

Yuanlong Li\(^1\), Zongli Lin\(^2\)
\(^1\)Shanghai Jiao Tong University, China; \(^2\)University of Virginia, USA

Multistability of biological systems with complex nonlinear regulatory schemes is an important research topic in system biology. In many models of biological systems, the regulatory functions are of saturation type. The linear sectors, in which the saturation type functions reside, have been extensively adopted to deal with these saturation type functions. The stability analysis resulting from linear sectors is however often conservative as a wide linear section is required to include a large portion of a saturation type function. In this paper, we utilize piecewise linear sectors, recently adopted in nonlinear control theory, to investigate multistability of a class of biological systems with sum regulatory schemes. We will estimate the domain of attraction of each stable equilibrium. A genetic toggle switch in Escherichia coli is employed as an example to illustrate the applicability and effectiveness of our analysis method.

Adaptive Output Regulation for General Output Feedback Nonlinear Systems with Integral ISS Inverse Dynamics
Dabo Xu\(^1\), Jie Huang\(^2\), Zhong-Ping Jiang\(^3\)
\(^1\)Nanjing University of Science and Technology, China; \(^2\)The Chinese University of Hong Kong, Hong Kong; \(^3\)Polytechnic Institute of New York University, USA

The output regulation problem for output feedback nonlinear systems with integral input-to-state (iISS) inverse dynamics was studied recently for the unity relative degree case. In this paper, we further study the same problem for the case where the relative degree is greater than one. For this purpose, we need to develop a recursive procedure to design an output feedback controller. An example will also be given to illustrate the design method.

Neuroadaptive Robust Control of Automatic Train Operation Subject to Actuator Saturation
Shigen Gao\(^1\), Hairong Dong\(^2\), Bin Ning\(^1\), Yao Chen\(^1\), Guanrong Chen\(^2\), Qingwen Liang\(^3\)
\(^1\)Beijing Jiaotong University, China; \(^2\)City University of Hong Kong, Hong Kong; \(^3\)China Communications Construction Company Limited, China

In this paper, neuroadaptive robust control problem for the automatic train operation (ATO) system under actuator saturation is considered. The saturation is caused by constraints from serving motors. A neuroadaptive robust control scheme is proposed. To cope with the actuator saturation, another neuroadaptive robust control scheme is proposed for the ATO system, by explicitly considering the actuator saturation nonlinearity other than unknown system parameters, which is proved capable of stabilizing the closed-loop system. The effectiveness of the proposed control schemes are verified via numerical simulations.

Distributed Control of Angle-constrained Circular Formations using Bearing-only Measurements
Shiyu Zhao, Peng Lin, Kemao Peng, Ben M. Chen, Tong H. Lee
National University of Singapore, Singapore

This paper studies distributed formation control of multiple agents in the plane using bearing-only measurements. It is assumed that each agent only measures the local bearings of their neighbor agents. The target formation considered in this paper is a circular formation, where each agent has exactly two neighbors. In the target formation, the angle subtended at each agent by their two neighbors is specified. We propose a distributed control law that stabilizes angle-constrained target formations merely using local bearing measurements. The stability of the target formation is analyzed based on Lyapunov approaches. We present a unified proof to show that our control law not only can ensure local exponential stability but also can give local finite-time stability. The exponential or finite-time stability can be easily switched by tuning a parameter in the control law.
A New Distributed Localization Method for Sensor Networks
Yingfei Diao¹, Zhixun Lin², Miuye Fu³, Huanshi Zhang⁴
¹Shandong University, China; ²Zhejiang University, China; ³University of Newcastle, Australia
This paper studies the problem of determining the sensor locations in a large sensor network using relative distance (range) measurements only. Our work follows from a seminal paper by Khan et al. [1] where a distributed algorithm, known as DILOC, for sensor localization is given using the barycentric coordinate. A main limitation of the DILOC algorithm is that all sensor nodes must be inside the convex hull of the anchor nodes. In this paper, we consider a general sensor network without the convex hull assumption, which incurs challenges in determining the sign pattern of the barycentric coordinate. A criterion is developed to address this issue based on available distance measurements. Also, a new distributed algorithm is proposed to guarantee the asymptotic localization of all localizable sensor nodes.

On Networked Non-Cooperative Games -- A Semi-Tensor Product Approach
Daizhan Cheng¹, Fenghua He², Tingting Xu³
¹Chinese Academy of Sciences, China; ²Harbin Institute of Technology, China
The networked competitive games are investigated, where each player (or agent) plays with all other players in his neighborhood. Assume the evolution is based on the fact that players use local strategy, that is, each player’s strategy depends on the previous information of its neighborhood players, including strategies and payoffs. Using sub-neighborhood, the dynamics of the evolution is obtained. Then Formula for calculating Nash equilibrium from mixed strategies of multi-players is proposed. The relationship between local Nash equilibriums on individual neighborhoods and global Nash equilibriums of overall network is revealed. Certain related properties are investigated. The basic tool of this approach is the semi-tensor product of matrices, which converts the strategies into logical matrices, the payoffs into pseudo-Boolean functions, and the evolutionary games become discrete time dynamic systems.

Improving Quadrotor Three Axes Stabilization Results Using Empirical Results and System Identification
Ovunc Elbir, Anil Ufuk Batmaz, Cosku Kasnakoglu
TOBB University of Economics and Technology, Turkey
In current literature, Unmanned Aerial Vehicles (UAVs), especially quadrotors, is one of the hot topics of study which has numerous applications. This paper focuses on modeling the quadrotor in order to improve the empirical results. The procedure consists of four stages: 1) Experimental determination of controller coefficients, 2) Data collection, 3) System identification, 4) Controller redesign. After these stages, it is observed that the system is capable of stabilize on the roll, pitch and yaw axes. Coefficient tuning on the identified model noticeably improves the settling time and steady state oscillation amplitude.

State Estimation in Discrete-Time Nonlinear Stochastic Systems Subject to Random Data Loss
S.M. Mahdi Alavi¹, Mehrdad Saif¹, Bahram Shafai²
¹University of Windsor, Canada; ²Northeastern University, USA
This paper focuses on observer design problem in discrete-time nonlinear stochastic systems subject to random data loss. A sufficient condition is derived which guarantees exponential mean-square stability of the estimation error for the problem at hand. An efficient algorithm is also proposed to obtain the observer gain. The effectiveness of the proposed observer design technique is extensively evaluated by applying it to a multi-input multi-output aerodynamic flight system.

Effectiveness of The DIDIM Method with Respect to The Usual CLOE Method. Application to The Dynamic Parameters Identification of An Industrial Robot
Anthony Jubien¹, Maxime Gautier², Alexandre Janot¹
¹ONERA The French Aerospace Lab, France; ²IRCCyN Institute /Research Institute of Communications and Cybernetics, France
Usual Closed Loop Output Error (CLOE) method for parameter identification of robot dynamics has several drawbacks: slow convergence, sensitivity to initial conditions, measurement of position needed and difficult computation of the relevance of the identified parameters. Recently a new CLOE method called DIDIM for Direct and Inverse Identification Model needing only actual forces/torques data was validated on rigid robots. This method avoids the drawbacks of usual CLOE method. In DIDIM method, the optimal parameters minimize the 2-norm of the error between the actual forces/torques and the simulated ones. It is based on a closed-loop simulation of the robot using the direct dynamic model, the same structure of control-law and the same reference trajectory for both the actual robot and the simulated one. The method simplifies dramatically the non-linear Least Squares problem using the Inverse Dynamic Model to obtain an analytical expression of
the simulated forces/torques, linear in the parameters. It allows to decrease dramatically the time of convergence. In this paper a study of the effectiveness of this new method compared to a usual CLOE method which uses the actual positions as output is performed on a 6 degrees of freedom industrial robot Stäubli TX40.

A Novel Method for Indirect Estimation of Tire Pressure
Selim Solmaz
Gediz University, Turkey

In this paper a novel algorithm for indirectly estimating predetermined levels of tire deflation of an automotive vehicle is described. The estimation method is based on measuring varying levels of lateral dynamics behavior due to certain types of tire failures that may include excessive deflation or significant thread loss. Given the fact that both failures will notably affect the lateral vehicle behavior, quantifying these levels of alteration in the lateral dynamical response forms the basis of the estimation method. In achieving this, multiple models and switching method is utilized based on linearized lateral dynamics models of the vehicle that are parametrized to account for the uncertainty in tire pressure levels. The results are demonstrated using representative numerical simulations.

A Unified Framework for State Estimation of Nonlinear Stochastic Systems with Unknown Inputs
Chien-Shu Hsieh
Ta Hwa University of Science and Technology, Taiwan

This paper considers the unknown input filtering problem of nonlinear stochastic systems with arbitrary unknown inputs. It is known that the celebrated extended Kalman filter (EKF) may have poor performance in solving this problem due to the lack of the true dynamics of the unknown input. A possible remedy to improve the performance is to apply an EKF-like nonlinear version of the recently developed ERTSF (NERTSF), which however may only yield a specific linear combination of the unknown input vector. In this paper, an unknown-input decoupled nonlinear estimation framework is proposed, through which specific derivative-based and -free estimators are derived to provide both the estimable and unestimable unknown input estimates. Applications to rederive the existing literature results are provided to illustrate the usefulness of the proposed results.

A Local Information Criterion for Order Identification of Nonlinear ARX Systems

We consider the local order estimation of nonparametric nonlinear autoregressive systems with exogenous inputs (NARX), which may have different local dimensions at different points of interest. By minimizing the kernel-based local information criterion introduced in the paper, the strongly consistent estimates for the local orders of the NARX system at of interest points are obtained. The theoretical result derived here is tested by a simulation example.

Adaptive Control of a Three-Agent Surveillance Swarm with Constant Speed Constraint
Samet Guler, Nasrettin Koksal, Baris Fidan
University of Waterloo, Canada

A hierarchical, decentralized controller is synthesized to control a swarm of three unmanned aerial vehicle agents to move in rigid formation on a plane for surveillance. First, lateral dynamic model for an individual agent is derived. Then, assuming constant speed restriction, the control task is approached considering a two-level control structure: low-level and high-level. A direct model reference adaptive controller is designed in the low-level, while in the high-level a switching logic is used considering different cases for inter-agent distances. The effect of constant speed values of individual agents is discussed in terms of the feasibility of formation during motion. Positive results obtained from simulations for two different reference trajectories consolidate the effectiveness of our algorithm.

A New Approach to Map Joining for Depth-Augmented Visual SLAM
Chien-Hung Liu, Kai-Tai Song
National Chiao Tung University, Taiwan

In this paper, a novel scheme is proposed to improve real-time performance of simultaneous localization and mapping (SLAM) of a mobile robot based on depth-augmented visual features. In this design, the robot has two stages in navigation applications, namely the map building stage and the map usage stage. In the map-building stage, a local map is built to join into the global map. For the map-usage stage, instead of using the global map, the local maps facilitate real-time path tracking control of the robot. Using of local maps has the merit of reducing the computational complexity of EKF-SLAM. In the map joining procedure, deviations of adjacent local maps are corrected based on local features. Loop closure detection
is used to determine whether the local map building is completed. A Kinect sensor is adopted to realize the proposed method. Navigation experiments on a wheeled mobile robot show that the motion error of robot localization is within 0.1m for a travel over 83m.

Singularity-Free Adaptive Control for Uncertain Omnidirectional Mobile Robots
Jeng-Tze Huang, Tran Van Hung
Chinese Culture University, Taiwan

Issues of control designs for omnidirectional mobile robots with parametric uncertainty, including the location of the center of the mass and the electrical constants, are addressed. First, the Lagrange method is used for deriving the system dynamics. Next, a singularity-free adaptive linearizing control is proposed to tackle with such a task. It ensures the asymptotic tracking stability and avoidance of control singularity at the same time. Simulation is carried out to demonstrate the validity of the proposed design in the final.

Connectivity Control on Lie Groups
Aykut C. Satici, Mark W. Spong
University of Texas at Dallas, USA

The preservation of connectivity in networks is critical to the success of existing algorithms designed to achieve various goals. Control laws increasing the connectivity of a given state-dependent graph have been formulated for agents evolving on the Euclidean space. In this paper, we show that similar control laws can be adapted to more general spaces. In particular, we consider agents whose configuration space is represented by a Lie group. In addition, we will require the resulting control law to be symmetric with respect to the natural group action, with the intention that additional controllers for the group action may be implemented on top of the connectivity controllers.

Energy Consumption Optimization for Mobile Robots in Three-dimension Motion Using Predictive Control
Mostafa I. Yacoub1, Dan S. Necsulescu1, Jurek Z. Sasiadek2
1University of Ottawa, Canada; 2Carleton University, Canada

As the demand for field mobile robots in off-road operations increased, the need to investigate the 3D motion for mobile robots became important. One of the main difficulties in the 3D motion of a mobile robot is the torque saturation of the DC motors of the wheels that occurs while climbing hills. In the present work, off-road conditions are utilized to benefit by avoiding torque saturation. Energy optimization algorithm using predictive control is implemented on a two-DC motor-driven wheels mobile robot while crossing a ditch. The developed algorithm is simulated and compared with the PID control and the open-loop control. The predictive control showed more capability to avoid torque saturation and noticeable reduction in the energy consumption. Furthermore, using the wheels motors armature current instead of the supply voltage as control variable in the predictive control showed more robust speed control. Simulation results showed that in case of knowing the ditch dimensions ahead of time, the developed algorithm is feasible.

Cooperative Coverage of Mobile Robots with Distributed Estimation and Control of Connectivity
Xiaoli Li, Shuguang Zhao, Haiqin Xu
Donghua University, China

This paper deals with the discrete-time connected coverage problem with the constraint that each robot of group can only sense and communicate in the local range. In such distributed framework, the algebraic parameter of connectivity, that is, the second smallest eigenvalue of topology Laplacian, is estimated by introducing the minimal-time consensus algorithm to guarantee the high cooperation efficiency. Since no certain edges are imposed to be preserved, the method of keeping the second smallest eigenvalue positive reserves a sufficient degree of freedom for the motion of robots in the connected group. Furthermore, a self-deployment algorithm is developed to disperse the robots with the precondition that the resulting second smallest eigenvalue keeps positive at each time-step. At last, we prove that the proposed algorithm steers each pair of neighbor robots to reach the largest objective distance from each other. It implies that the distributed optimal coverage is achieved under the connectivity constraint.

Cooperative Electricity Consumption Scheduling and Pricing for Future Residential Smart Grid
Guohua Jiang1, Li Yu1, Yuan Wu1, Wenzhan Song2
1Zhejiang University of Technology, China; 2Georgia State University, USA

Smart Grid, with its advanced two-way communication mechanism, has been envisioned to improve efficiency and stability of grid operation significantly. One of the key features of smart grid is its flexible demand response mechanism based on which the energy consumers are able to schedule their energy consumptions wisely over time to trade off between its
utility and the associated energy-acquisition cost. The key ingredient in consumers’ demand response is the electricity price, which is normally determined and controlled by the electricity providers or retailer. As a result, the consumers usually suffer from a potential loss of welfare due to this “unfair” pricing scheme dominated by the providers. Motivated by this consideration, in this paper we propose a cooperative energy scheduling and pricing scheme, which allows the consumers to jointly optimize its electricity consumption and his preferred payment, based on the Nash Bargaining Solution (NBS) from the microeconomics theory. Our numerical results show that the proposed scheme can effectively improve both consumers’ net-welfare and provider’s net-profit compared to the non-cooperative case.

**Pricing-based Resource Allocation with Security Requirements for OFDM Networks in Real-Time Electricity Market**

Yue Zhang, Bo Yang, Cailinear Chen, Xinpeng Guan  
Shanghai Jiao Tong University, China  

In this paper, we propose a pricing-based cross-layer scheduling and energy management for secure data transmission in orthogonal frequency division multiplexing (OFDM) wireless networks. We try to investigate how to maximize the expected profit while ensuring the least electricity cost in the context of smart grids. To decrease the electricity cost, the base station is equipped with energy storage, such as uninterrupted power supply (UPS). Based on the time-varying power price, the UPS is charged and discharged at low and high power price, respectively. A pricing scheme is also proposed for the wireless operator to charge downlink user with security demand. The prominence of our proposed scheduling design is that it can be easily implemented without any statistic knowledge of electricity pricing. Theoretical analysis shows that the proposed scheme can achieve a near-optimal performance and that its effectiveness and robustness is also validated through simulation results.

**Energy Consumption Scheduling in Smart Grid: A Non-Cooperative Game Approach**

Kai Ma1, Guoqiang Hu2, Costas J. Spanos3  
1Nanyang Technological University, Singapore; 2University of California, USA  

This paper is concerned with an energy consumption scheduling problem for consumers in smart grid, based on a real time pricing strategy. Firstly, the energy consumption scheduling problem is cast into a non-cooperative energy consumption game, where consumers compete with each other in order to minimize their electricity usage cost. Secondly, we prove that the non-cooperative energy consumption game has a unique Nash equilibrium point, i.e., optimal energy consumption solution. Thirdly, the energy consumption solution is obtained by a discrete iterative algorithm. Simulation results show that the energy consumption scheduling scheme is effective in matching the varying generation capacity in a day.

**Optimal Residential Load Scheduling in Smart Grid: A Comprehensive Approach**

Bo Chai, Zaiyue Yang, Jiming Chen  
Zhejiang University, China  

In this paper, as a fundamental problem in smart grid, the residential load scheduling is studied in a comprehensive way. The main contributions lie in twofold. First, three indices, i.e., the power consumption expense, the robustness of schedule subject to uncertain electricity price and the satisfaction of customer, are taken into full consideration. We propose to optimize simultaneously the three indices via convex optimization. Second, in order to fully characterize the operation states of appliances, both binary and continuous variables are used, which results in a hybrid optimization problem. The relaxation technique is utilized to tackle the hybrid optimization problem. The performance of the proposed approach is illustrated by simulations. Both peak-to-average ratio of power load and variation of power load are reduced.

### 25th June, Tuesday  
14:00 - 15:40 at Barbaros A  
TuB6 Nonlinear Control (III)  

Session Chair: Ussama Ali, Mohammad Ali Jinnah University, Pakistan  
Session Co-Chair: Ilker Tanyer, Izmir Institute of Technology, Turkey

**Robust Adaptive Control of Nonlinear Systems with Unknown State Delay**

Alper Bayrak1, Enver Tatlicioglu1, Baris Bidikli1, Erkan Zergeroglu2  
1Izmir Institute of Technology, Turkey; 2Gebze Institute of Technology, Turkey  

In this work, we propose a new robust adaptive controller for a class of multi-input multi-output nonlinear systems subject to uncertain state delay. The proposed method is proven to yield semi-global asymptotic tracking despite the presence of additive input and output disturbances and parametric uncertainty in the system dynamics. An adaptive desired system compensation in conjunction with a continuous nonlinear integral feedback component is utilized in the design of the controller and Lyapunov-based techniques, are used to prove that the tracking error is asymptotically driven to zero. Numerical simulation results are presented to demonstrate the effectiveness of the proposed method.
Lateral Control of UAVs: Trajectory Tracking via Higher-Order Sliding Modes
Syed Ussama Ali, M. Zamurad Shah, Raza Samar, Aamer Iqbal Bhatti
Mohammad Ali Jinnah University, Pakistan
Nonlinear sliding mode approach is developed in this paper for lateral control of UAVs. The enabling guidance and control has achieved good performance with different flight conditions and evasive maneuvers. The proposed strategy can recover from large track errors without effecting the saturation constraints on the control input. The structure of guidance and flight control system is designed in a two loop configuration. The main contribution of this work is the development of new guidance scheme in which inner loop dynamics are also considered during the derivation of outer guidance loop for robust lateral control and never forcing unsuitable commands. HOSM (Higher-Order Sliding Mode) Real Twisting Algorithm is used because of relative degree 2 constraint, which maintains $SS$ and $S\dot{S} = 0$. The outer loop for guidance uses heading error angle, lateral track error and bank (roll) angle $\phi$ for the control law and PD controller is used in the inner loop. The designed guidance control system’s robustness and performance is verified via computer simulations using high fidelity nonlinear 6-degrees-of-freedom (6-dof) Yak-54 UAV model under different scenarios, with small and large track errors and in the presence of wind disturbances.

Sliding Mode Based Direct Torque Control of Three-Level Inverter Fed Induction Motor Using Switching Vector Table
Tanvir Ahammad, Abdul R. Beig, Khalifa H. Al Hosani
The Petroleum Institute, United Arab Emirates
This paper presents two sliding surfaces to control stator flux magnitude and developed torque of the motor. Sliding surfaces enforce the control variables to the respective reference values. A three-level switching vector table (SVT) approach is used to implement sliding mode direct torque control (SM-DTC) of induction motor drive. The SVT is formed using stator flux position in the space vector region of three-level inverter by observing the most significant vector that reflects effective change of flux magnitude and torque in that position. This switching table is simple and gives proper selection of space vector for improved performance of the direct torque control (DTC). Hence, the proposed SM-DTC reduces the complexity of DTC drive, improves the performance of the drive through reducing flux, torque and current ripples. The system is simulated in MATLAB/SIMULINK environment and simulation results are presented to report the improved performance of sliding mode based direct torque control dive.

A Robust Dynamic Inversion Technique for Asymptotic Tracking Control of an Aircraft
İlker Tanyer1, Enver Tatlicioglu1, Erkan Zergeroglu2
1İzmir Institute of Technology, Turkey; 2Gebze Institute of Technology, Turkey
In this paper, a tracking controller is developed for an aircraft model subject to uncertainties in the dynamics and additive state-dependent nonlinear disturbance-like terms. In the design of the controller, dynamic inversion technique is utilized in conjunction with a robust term. Only the output of aircraft dynamics is utilized in the controller design and acceleration measurements are not required. Lyapunov based stability analysis is used to prove global asymptotic tracking.

Numerical Analysis of a Reparable Multi-State Device
Houbao Xu1, Weiwei Hu2
1Beijing Institute of Technology, China; 2University of Southern California, USA
A numerical scheme is formulated for approximating the dynamic behavior of a reparable multi-state device, which can be described as a distributed parameter system of coupled partial and ordinary hybrid equations. The convergence issues are established by applying the Trotter-Kato Theorem, and simulation results show the effectiveness of the proposed scheme.
Automotive longitudinal speed pattern generation with acceleration constraints aiming at mild merging using model predictive control method

Wenjing Cao¹, Masakazu Mukai¹, Taketoshi Kawabe¹, Hikaru Nishira², Noriaki Fujiki²

¹Kyushu University, Japan; ²Nissan Motor Co., Ltd., Japan

To ensure safety and simplicity in merging path generation for a realistic reliable and mild merging, this paper proposes a merging path generation method. In the proposed method, the merging problem is considered in two-dimensional space and formulated into a one-dimensional space optimization problem by relating the longitudinal motion of the merging vehicle to the lateral motion of it. In this way the optimization problem would be much simpler and therefore the computational time could be shorter than formulating it into a two-dimensional problem. Moreover, the parameters are chosen appropriately so that the variation of the acceleration of the main lane vehicle is less severe than that of the merging vehicle, which is consistent with the practice. To realize mild merging, the merging path is optimized while the accelerations of the relevant vehicles are optimized through the model predictive control (MPC) method. With the proposed method, the merging vehicle can merge smoothly and realistically in cooperative with the main lane vehicle. The effectiveness of this method is verified by a computer simulation of the motions of one merging vehicle and one main lane vehicle. The initial conditions of the merging are set realistically according to the data drawn from actual merging scenes. The results proved that, with the proposed method the merging vehicle can merge mildly in cooperation with the main lane vehicle.

A Comparative Study of Two Control Schemes for Anti-Lock Braking Systems

Samuel John¹, Jimoh O. Pedro²

¹University of Science and Technology, Namibia; ²University of the Witwatersrand, South Africa

The commercial anti-lock braking system has several short-comings. Therefore, there is the need for continual improvement on the ABS control strategy. One of the problems associated with these short-comings includes the physical shock experienced by drivers through the brake petal pulsation, when the system is activated. A non-linear and a neural network-based alternative ABS control schemes are proposed and evaluated. The main goal is for the ABS controller to maintain optimal system performance in terms of slip regulation and minimising the vehicle stopping distance during hard-braking. A comparative analysis of the two ABS controllers based on simulation results, showed the neural network-based controller to be superior.

Compound Control for Intelligent Artificial Leg Based on Fuzzy-CMAC

Hongliu Yu, Jinhua Yi, Ping Shi

University of Shanghai for Science and Technology, China

The features of complex system model, such as nonlinearity and parameter uncertainty, in the Intelligent Artificial Leg (IAL) system determines the need of intelligent control methods. On the other hand, the traditional mathematic model is not suitable for the actual control because the IAL knee torque is indirectly caused by the nonlinear damping at the knee joint. A dynamic model of a self-made hydraulic IAL with the nonlinear damper control parameters and hip torque was established, and an inverse dynamic compound controller of PD/Fuzzy-CMAC for tracking the knee swing was designed in the paper. A case simulation shows that an arbitrary trajectory like a desired walking pattern can be tracked in less than 5 seconds, which proves that the designed controller has high performance of real-time and precision.

A Cascade Controller Structure using an internal PID controller for a Hybrid Piezo-Hydraulic Actuator in Camless Internal Combustion Engines

Paolo Mercorelli¹, Nils Werner²

¹Leuphana University of Lueneburg, Germany; ²Ostfalia University of Applied Sciences, Germany

This paper presents a hybrid actuator composed by a piezo and a hydraulic part and with a cascade PI-PID-Pi control structure for camless engine motor applications. The idea of this contribution is using the advantages of both: the high precision of the piezo and the force of the hydraulic part. Piezoelectric actuators (PEAs) are mostly used for precision positioning, despite PEAs present nonlinearities, such as saturations, hysteresis and creep. In the control problem this kind nonlinearities must be taken into consideration. The Preisach dynamic model with the above mentioned nonlinearities is considered along with a cascade PI-PID-Pi in this contribution. In particular, the hysteresis effect is considered and a model with a switching function is used also for the controller design. Simulations with real data are presented.
The Development of Electromechanical Valve Actuator and the Comparison with the Camshaft Driven System
Zeliha Kamis Kocabicak, Elif Erzan Topcu, Ibrahim Yuksel
Uludag University, Turkey

Electromechanical valve actuators (EVAs) are new technology devices used in gasoline engines. They improve engine performance via flexibility in valves timings at all engine operating conditions. In this paper a suitable model of the EVA used disc type of cylindrical magnetic circuits is designed and compared with the conventional camshaft driven system. The static and dynamic equations of the system are derived and their numerical solutions are obtained in order to identify the static and dynamic performance of the EVA. A prototype of the EVA was built and some preliminary tests were carried out on it.

Optimal Controller Design for a Railway Vehicle Suspension System Using Particle Swarm Optimization
Hazlina Selamat1, Siti Duranni Arang Bilong2
1Universiti Teknologi Malaysia, Malaysia; 2Universiti Tun Hussein Onn Malaysia, Malaysia

This paper presents the design of an active suspension control of a two-axle railway vehicle using an optimized linear quadratic regulator. The control objective is to minimize the lateral displacement and yaw angle of the wheelsets when the vehicle travels on straight and curved tracks with lateral irregularities. In choosing the optimum weighting matrices for the LQR, the Particle Swarm Optimization (PSO) method has been applied and the results of the controller performance with weighting matrices chosen using this method is compared with the commonly used, trial and error method. The performance of the passive and active suspension has also been compared. The results show that the active suspension system performs better than the passive suspension system. For the active suspension, the LQR employing the PSO method in choosing the weighting matrices provides a better control performance and a more systematic approach compared to the trial and error method.

Velocity Planning to Optimize Traction Losses in a City-Bus Equipped with Permanent Magnet Three-Phase Synchronous Motors
Paolo Mercorelli
The Leuphana University of Lueneburg, Germany

This contribution proposes a design technique the goal of which is minimizing power consumption of a City-Bus Equipped with Permanent Magnet Three-Phase Synchronous Motors. A constrained optimization problem is formulated and its solution is approximated by exploiting local flatness and physical properties of the system. The problem is posed as a two-point boundary value optimization problem that clearly takes into account the structural physical constraints and the properties of the system. This paper verifies the efficacy of the suggested method by means of simulations of a synchronous motor used in automotive applications.

Stability Analysis of Symmetrical Two-Route Traffic Flow with Feedback Information Delay
Yuki Iguchi, Kazuma Sekiguchi, Mitsuji Sampei
Tokyo Institute of Technology, Japan

Traffic information feedback strategies have the potential to improve the efficiency of traffic flow. There is a processing delay in providing the information, and the delay sometimes makes the traffic flow unstable. In this study, a relationship between the stability of traffic flow of the Symmetrical Two-Route with providing traffic information and the information delay is analyzed. The type of provided traffic information is vehicle number on each route. It is assumed that drivers choose one route by reference to the information. The dynamics of the traffic flow is described by the delay differential equation. By analyzing the equation, a sufficient condition for stability of the traffic flow is presented. Moreover, the validity of the condition is confirmed by numerical simulations using the Stochastic Optimal Velocity model, which is one of the realistic traffic models.

Traffic Scenes Invariant Vehicle Detection
Yan Liu1,2,3, Xiaoqing Lu1, Jianbo Xu2
1Peking University, China; 2State Key Laboratory of Digital Publishing Technology, China; 3Postdoctoral Workstation of the Zhongguancun Haidian Science Park, China

Although lots of vehicle detection methods can implement vehicle detection with high performance, most of their application is confined by traffic scenes. The detection precision may change heavily with traffic congestion extent, illumination variance and vehicle moving speed. To overcome the problem of weak traffic scene adaptability, a robust vehicle detection method is proposed using the inter-relationship of consecutive multi-frames. The changing of frame content is a process including abrupt and gradual variation caused by the objects’ color and intensity changing. Thus, the
local maxima of consecutive frames' objective function are constructed to determine the best vehicle detection frame. This function is invariant to traffic congestion and vehicle speed, and avoids vehicle segmentation from frames. For illumination invariance, traditional threshold method is substituted by peak searching method. Experiments show that the proposed method implements stably in different traffic scenes than traditional methods, and with the real-time performance and higher detection precision.

25th June, Tuesday
16:20-17:40 at Malazgirt 2
TuC3  AI and Expert Systems
Session Chair: Hyun Seung Son, Yonsei University, South Korea
Session Co-Chair: Bingqiang Huang, Zhejiang University, China

Online ANFIS Controller Based on RBF Identification and PSO
Ali Moltajaie Farid$^1$, S. Masoud Barakati$^1$, Navid Seifipour$^1$, Navid Tayebi$^2$
$^1$University of Sistan and Baluchestan, Iran; $^2$Yildiz Technical University, Turkey
Adaptive neuro-fuzzy inference system (ANFIS) is combining a neural network with a fuzzy system results in a hybrid neuro-fuzzy system, capable of reasoning and learning in an uncertain and imprecise environment. In this paper online training of ANFIS is done using radial basis function (RBF) neural network. In this online approach, identification of controlled plant is done, and based on this identification, the weights and coefficients are adjusted timely. Finally, to overcome initialization problem, using Particle swarm optimization (PSO) as an evolutionary algorithm is proposed.

The Study on Tracking Algorithm for the Underwater Target: Applying to Noise Limited Bi-Static Sonar Model
Hyun Seung Son$^1$, Jin Bae Park$^1$, Young Hoon Joo$^2$
$^1$Yonsei University, South Korea; $^2$Kunsan National University, South Korea
For the covertsness in modern anti-submarine warfare (ASW), the sonar system has been evolved to the bistatic type. However, it is difficult to get the recognizable error coefficient at any time with clear mathematical definition for the sonar model. To resolve the dynamics accompanied with the error component, we should deal with heterogeneous, complementary fusion of information in order to enable robust target detection, classification, localization, and tracking. In the tracking point of view, intelligent methods are urgent to overcome the shortage of the complex sum of errors. Hence, we concentrate on the increment of tracking error occurred from the target’s maneuvering owing to the acceleration. From the measurement residual, compensating acceleration by merging the filter with fuzzy c-means (FCM) clustering is proposed and this enables the ambiguous term in the sonar equation to be definite. Finally, an experiment is provided to show the effectiveness of the proposed algorithm.

Mining At Most Top-K% Mixed-drove Spatio-temporal Co-occurrence Patterns
Zhanquan Wang$^1$, Xuanhuang Peng$^1$, Chunhua Gu$^1$, Bingqiang Huang$^2$
$^1$East China University of Science and Technology, China; $^2$Zhejiang University, China
Discovering MDCOPs is an important problem with many spatio-temporal applications such as identifying planning and strategy in battlefield and tracking predator-prey interactions. However, it is hard to determine the appropriate interest measure thresholds. In this paper, the problem of mining at most top-K% MDCOPs without using user-defined thresholds is defined, and a novel mining algorithm based on time aggregated graph is proposed. Analytical and experimental results show that the TopMDCOP Graph Miner is correct and complete. Results show the proposed algorithm is computationally more efficient than the naive algorithm by using a new storage method to mine, it’s proved to be effective and validate in the real world. This electronic document is a “live” template and already defines the components of your paper [title, text, heads, etc.] in its style sheet.

Using General Sound Descriptors For Early Autism Detection
Seyyed Hamid R. Ebrahimi Motlagh$^1$, Hadi Moradi$^1$, Hamidreza Pouretemad$^2$
$^1$University of Tehran, Iran; $^2$Shahid Beheshti University, Iran
Early detection of autism is crucial for successfully dealing with it and reduce/eliminate its effects. In other words, early treatment can make a big difference in the lives of many children with this disorder. Consequently, in this study the pattern recognition algorithms are used to determine the unique features of the voice of autistic children to distinguish between the autistic children and normal children between ages 2 and 3. These descriptors extract various audio features such as temporal features, energy features, harmonic features, perceptual and spectral features. Two feature selection methods are used and the results are compared. One method is based on comparing the effect of using all of a group features together and another method compares the effect of using features one by one. The selected features are used to classify selected children into autistic and non-autistic ones. The results show 96.17 percent accuracy. After feature selection, we classified data using S.V.M classifier for recognizing two types of input data.
**Low-Oscillation Command Switch-Times for Relay-Driven Cranes with Asymmetrical Acceleration and Deceleration**

Kevin Chen-Chih Peng, William Singhose  
*Georgia Institute of Technology, USA*

Cranes powered by relay-controlled circuits constitute an important set of industrial cranes used throughout the world. Due to their simplicity, ruggedness, and long service life, this type of crane can be found in older factories or in applications where precise motion control is not a strict requirement. However, controlling payload oscillations on this type of crane is challenging for two reasons: 1) Relays that can only be turned on or off allow for only limited control over the crane trolley velocity; and 2) These cranes typically have nonlinear asymmetrical acceleration and deceleration properties. This paper presents a method for determining the relay switch-times that move payloads with low residual oscillation. First, a closed-form equation for the residual oscillation given an arbitrary input motion is derived. Second, the relationship between crane trolley motion and switch-times is established. Finally, numerical searches are used to determine minimal-oscillation switch-times.

**Oscillation Suppressing for an Energy Efficient Bridge Crane Using Input Shaping**

Youmin Hu1, Joshua Vaughan1, William Singhose1, Bo Wu1  
1HuaZhou University of Sci. & Tech, China; 2University of Louisiana at Lafayette, USA; 3Georgia Institute of Technology, USA

The traditional bridge crane (TBC) waste a large amount of energy because of low positioning precision and payload oscillation. The energy efficient bridge crane (EEBC) is a new prototype crane that adds a Micro Bridge fine-positioning stage to the typical dual-bridge crane. With this Micro/Macro dual-bridges design, the new crane has the potential to save energy and promote positioning precision. A planar dynamic model of the EEBC is developed in the paper. Then, the dynamics performance of the EEBC is analyzed. A ZV input shaper is used to suppress the oscillation of payload and improve payload-positioning accuracy. The results show that the EEBC has the potential advantages of saving energy and promoting positioning precision.

**Experimental Testing of Liquid Slosh Suppression in a Suspended Container with Compound Pendulum Dynamics**

Ali AlSaibie, William Singhose  
*Georgia Institute of Technology, USA*

Liquid slosh is a concern for industries that move liquids as part of their operations. The majority of existing control techniques utilize feedback control to reduce liquid slosh. On the other hand input shaping has shown to be robust and effective in minimizing liquid slosh without the use of sensors. This paper examines through experimentation the use of a wide range of input shapers to reduce liquid slosh. The container used in the experiments is suspended and exhibits compound pendulum dynamics. Test results demonstrate the effectiveness and robustness of input shaping in reducing liquid slosh and the ability to provide fast settling times over a broad range of frequency variations. The results also provide a thorough comparison of several different types of input shaping. These results will help guide engineers working on slosh control problems.

**Spectral Features of ZVD Shapers with Lumped and Distributed Delays**

Tomas Vyhlidal, Vladimir Kucera, Martin Hromcik  
*Czech Technical University in Prague, Czech Republic*

An interesting spectral property, related to sensitivity of ZVD shaper zeros with respect to small deviations of involved delays, is presented in the paper. Consequences concern namely feedback interconnections as indicated in the report. Compared to the lumped-delay case, the recently proposed distributed delay alternative - ZVD shaper with distributed delay - is a more robust option, as explained and demonstrated by means of roots diagrams. Several examples are presented to demonstrate the phenomena.

**Modeling and Control of Rocking in Cable-Riding Systems**

Joshua Vaughan  
*University of Louisiana at Lafayette, USA*

Cable-riding suspended systems are commonplace, with applications ranging from ski lifts to tramways to material movers in mining operations. Another, more recent application is the robotic inspection of cables using robots that ride along the cables which they are inspecting. The Expliner robot is one such device. It inspects live, high-voltage power lines while moving along them. For all of these cable-suspended systems, rocking oscillation can reduce safety and efficiency of operation. This paper presents a model to identify the key dynamic factors of this rocking motion. Then, input shaping is used to limit rocking from both motion along the cable and controlled center-of-mass shifts.
Real-Time Implementation of A Robust Hierarchical Controller for A Laboratory Helicopter
Hao Liu, Geng Lu, Yisheng Zhong
Tsinghua University, China
In this paper, robust control problem is addressed for a three degree-of-freedom (3-DOF) laboratory helicopter. This helicopter system has three angles: the elevation, pitch, and travel angles and is a nonlinear multiple-input multiple-output (MIMO) uncertain system. The proposed controller is a robust hierarchical controller, which consists of a position controller and an attitude controller. The desired reference of the pitch angle is generated by the position controller based on the tracking error of the travel angle. Reference tracking of the pitch and elevation angles is achieved by the attitude controller. The tracking errors of the three angles are proven to converge ultimately into the given neighborhoods of the origin. Experimental results are also given to demonstrate the effectiveness of the proposed control strategy.

Robust Stability Analysis of An Optical Parametric Amplifier Quantum System
Ian R. Petersen
University of New South Wales at the Australian Defence Force Academy, Australia
This paper considers the problem of robust stability for a class of uncertain nonlinear quantum systems subject to unknown perturbations in the system Hamiltonian. The case of a nominal linear quantum system is considered with non-quadratic perturbations to the system Hamiltonian. The paper extends recent results on the robust stability of nonlinear quantum systems to allow for non-quadratic perturbations to the Hamiltonian which depend on multiple parameters. A robust stability condition is given in terms of a strict bounded real condition. This result is then applied to the robust stability analysis of a nonlinear quantum system which is a model of an optical parametric amplifier.

On Smith Predictor-Based Controller Design for Systems with Integral Action and Time Delay
Ugur Tasdelen, Hitay Ozbay
Bilkent University, Turkey
A new Smith predictor based controller is proposed for systems with integral action and flexible modes under input-output time-delay. The design uses controller parametrization and aims to achieve a set of performance and robustness objectives. Compared to existing Smith predictor based designs, disturbance attenuation property is improved, with respect to periodic disturbances at a known frequency. A two-degree of freedom controller structure is shown to be helpful in shaping the transient response under constant reference inputs. Stability robustness properties of this system are also investigated. Simulation results demonstrate the effectiveness of the proposed controller.

Nonlinear Inventory Control with Discrete Sliding Modes in Systems with Multiple Delayed Supply Options
Przemyslaw Ignaciuk
Lodz University of Technology, Poland
In this paper, the concept of discrete sliding modes (DSMs) is applied to develop an efficient control strategy for a class of perturbed processes with delay — goods flow control in supply chain. In the considered systems, the stock used to satisfy the unknown, time-varying demand placed at a goods distribution center is replenished with delay from a number of supply sources. In the analyzed setting, the order quantity is fixed leaving the time between the consecutive orders as a decision variable, which perfectly suits the switching nature of input signals obtained in DSM control systems. It is proved that with the proposed strategy applied the stock level does not exceed the assigned storage space and full demand satisfaction is achieved.

Multivariable PID Controllers for Dynamic Process
Mashitah Che Razali, Norhaliza Abdul Wahab, Pedro Balaguer, Mohd Fuaad Rahmat, Sharatul Izah Samsudin
1 Universiti Teknologi Malaysia, Malaysia; 2 Universitat Jaume I de Castello, Spain; 3 University Teknikal Malaysia Melaka, Malaysia
This paper is concerned with the design of a dynamic multivariable PID control for multi input multi output (MIMO) process. Four multivariable PID control schemes using Davison, Penttinen-Koivo, Maciejowski and a combined method were applied. The controller parameters for all control strategies were designed based on dynamic condition using singularly perturbed system. The purpose of the study is to investigate the effectiveness in the performance of dynamic control based on different multivariable PID control strategies. To attain the best result, numerous tuning parameters were tested. The simulation results show the significance of the study whereby the proposed dynamic MPID control scheme shows better improvement in control tuning of nonlinear system.
Robot Aided Passive Rehabilitation using Nonlinear Control Techniques
Mohammad Habibur Rahman¹, Philippe S. Archambault¹, Maarouf Saad², C. Ochoa-Luna², S.B. Ferrer²
¹McGill University, and Center for Interdisciplinary Research in Rehabilitation (CIRIR), Canada; ²École de Technologie Supérieure (ETS), Canada

This paper presents a robot aided passive arm movement therapeutic scheme. A seven DoFs robot, ETS-MARSE (motion assistive exoskeleton robot for superior extremity) was used for this purpose. It is an exoskeleton type wearable robot, which was designed corresponds to human upper-limb biomechanics, to provide movement assistance and rehabilitation to the individuals with upper limb dysfunction due to conditions such as stroke or spinal cord injuries. Considering the dynamic modeling of the exoskeleton which nonlinear in nature, we have employed nonlinear control techniques (sliding mode and computed torque) to maneuver the exoskeleton. Experiments were carried out with healthy male human subjects where trajectories tracking in the form of passive rehabilitation exercises were performed.

Modeling and Control of An Electric Drive System with Continuously Variable Reference, Moment of Inertia and Load Disturbance
Alexandra-Iulia Stinean¹, Stefan Preitl², Radu-Emil Precup¹, Claudia-Adina Dragos¹, Mircea-Bogdan Radaç¹, Emil M. Petriu²
¹Politehnica University of Timisoara, Romania; ²University of Ottawa, Canada

This paper presents applicative aspects concerning the modeling, simulation, analysis and design of control solutions for a direct current electric drive system with continuously variable reference input (speed), variable moment of inertia and variable load disturbance. Two variable control structures for speed control are treated. The structures employ the switching between three or more control algorithms, and their design is based on the detailed mathematical model of the plant and on the particular features of the drive system. Conventional and fuzzy control solutions are offered as they are advantageous with respect to the continuous parameter adaptation because of the simplicity of adaptation at representative operating points. The solutions are validated by a digitally simulated application with fixed parameters and tested on a strip winding system laboratory equipment as a representative mechatronics system application.

Intelligent Systems Based Solutions for the Kinematics Problem of the Industrial Robot Arms
Emre Sariyildiz¹, Kemal Ucak², Kouhei Ohnishi¹, Gulay Oke², Hakan Temeltas²
¹Keio University, Japan; ²Istanbul Technical University, Turkey

In this paper, three intelligent system methods namely Artificial Neural Network (ANN), Support Vector Machine (SVM) and Adaptive Neuro Fuzzy Inference Systems (ANFIS), are implemented to solve the inverse kinematics problem of the industrial robot arms. The main advantages of the intelligent system based solutions in the robot kinematics are that they can be easily implemented in analysis of complex mechanisms and their solutions do not suffer by the singularity that is one of the fundamental problems of inverse kinematics. The screw theory and quaternion algebra based kinematic model is used to improve the model efficiency by decreasing the computational complexity and load. The kinematics problem of the Staubli TX-60L industrial robot arm is analyzed by using the proposed intelligent system based solutions and simulation results are given.

Leader-Follower Formation Control of Nonholonomic Wheeled Mobile Robots using only Position Measurements
Hasan A Poonawala, Aykut C Satici, Mark W Spong
University of Texas at Dallas, USA

This paper deals with the formation control problem for a team of nonholonomic wheeled mobile robots. Each robot has a leader robot with respect to which a constant relative position is to be maintained, except for a single robot which defines the motion of the formation. We present a feedback control method that guarantees convergence of the relative position of any follower robot (with respect to its leader) to desired values. The controller does not require sensing of the leader’s velocity. Instead, an adaptive method is used to estimate the leader’s forward velocity. We show that the resulting closed loop system is semi-globally asymptotically stable. Simulation results are presented in order to demonstrate the performance of the controller for two robots, and a team of mobile robots.

Control of Soccer Robots Using Behaviour Trees
Rahib A. Abiyev, Nurullah Akkaya, Ersin Aytaç
Near East University, Turkey

In the paper a novel behaviour tree based control used in decision making processes of robot soccer is proposed. Decision Making (DM) is a basic block of robot that analyses the current state of world model and makes decision about new positions of robots. Proposed behaviour tree (BT) has high and low level behaviours and its nodes are operating using certain behaviour rules given in the paper. High level behaviours are implemented using low level behaviours. The new
behaviours of soccer robots are designed using tree structure. The use of BT approach allows to model complicated situations easily that show advantages of this technique over finite state machines widely used in robot control. After defining behaviours and making decisions, path finding module determines the path of robot. In the paper the integration of a Rapidly Exploring Random Tree (RRT) with path smoothing techniques is developed to find the path of the robot in a short time. The obtained simulation and experimental results show that the constructed navigation system of soccer robots efficiently finds desirable and feasible solutions in short amount of time.

A Non-Communicating Multi-Robot System with Switchable Formations
Ahmet Cezayirli\textsuperscript{1}, Feza Kerestecioglu\textsuperscript{2}
\textsuperscript{1}Forevo Digital Design Ltd., Turkey; \textsuperscript{2}Kadir Has University, Turkey

We consider connected navigation of autonomous mobile robots with transitions in the group formation. The robots navigate using simple local steering rules without requiring explicit communication among themselves. The formations are achieved by designing proper cost functions and formation transitions are succeeded by switching among these cost functions. The resulting system is proven to be deadlock-free under certain conditions.
A New Method of Direct Data-driven Predictive Controller Design
Hua Yang, Shaoyuan Li
Ocean University of China, China; Shanghai Jiao Tong University, China
In this paper, we try to find a direct path between data and predictive controller. A straightforward data-driven predictive controller for the linear multivariable systems is proposed, without identifying any representation of the system in an intermediate step. The minimal image representation is used to describe the controlled linear multivariable system instead of model or dynamical description matrix. Data-based prediction can be estimated directly from an input/output trajectory of the system and thus the computation of dynamic optimization. For the unconstrained condition, control laws can be analytically determined directly from the data Hankel matrices without model or any intermediate step to meet the given performance specifications. The proposed predictive controller is demonstrated on a multivariable system.

Data-driven Based Predictive Controller Design for Vapor Compression Refrigeration Cycle System
Xiaohong Yin, Shaoyuan Li, Jing Wu, Ning Li, Wenjian Cai, Kang Li
Shanghai Jiao Tong University, China; Nanyang Technological University, Singapore; Queen's University, UK
Data-driven control approaches have been widely applied in the modern industrial process control. A multivariable data-driven based controller using model predictive control strategy for the vapor compression refrigeration cycle system is proposed in this paper. For the purpose of further simplification of the controller design, a 3rd-order model has been got by model reduction based on the singular perturbation method, and the accuracy of which has been confirmed by the comparisons of dynamic response characteristics among the nonlinear model, linearized model and reduced-order model. The effectiveness of the proposed controller is verified on an experimental system.

An Iterative Predictive Learning Control Approach With Application to Train Trajectory Tracking
Heqing Sun, Zhongsheng Hou
Beijing Jiaotong University, China
An approach of iterative predictive learning control (IPLC) is proposed for the control of train trajectory tracking. Through combining iterative learning control with predictive control method, the iterative predictive learning control for input-affine nonlinear systems is formulated and solved in this paper. Its application to train trajectory tracking is detailed. Rigorous theoretical analysis confirms that the proposed approach can guarantee the asymptotic convergence of train speed and position to desired profiles along iteration axis. Simulation result shows its effectiveness and feasibility.

Neural Network based Model Predictive Control Performance Monitoring-Data-driven Approach
Lu Wang, Ning Li, Shaoyuan Li, Kang Li
Shanghai Jiao Tong University, China; Queen’s University, UK
A data-driven neural network based approach for model predictive control performance diagnosis was proposed. Considering four common MPC degradation factors, namely noise variance change, model mismatch, control variables constraint saturation, and manipulated variables constraint saturation, MPC performance patterns were divided into four categories. Performance signatures are extracted from the process input and output variables directly, and classifier is constructed via neural network. The effectiveness of the proposed method was demonstrated on NIAT platform by a two tank liquid level process.

Data-driven Water Supply System Modeling
Yuan Zhang, Jing Wu, Ning Li, Shaoyuan Li, Kang Li
Shanghai Jiao Tong University, China; Queen’s University, UK
Nowadays, the structure and properties of water supply system are becoming more and more complex, and modeling is becoming increasingly difficult. In this paper, a data-driven subspace identification method is presented. Firstly, a brief introduction for water supply systems is presented; after that, we get the I/O data through the InfoWorks WS software; at last, a data-driven subspace identification method is applied to get the model. The result of the experiment shows the effectiveness of the proposed method.
Performance Limitations in the Control of LTI Plants over Fading Channels
Alejandro I. Maass, Eduardo I. Silva
Universidad Tecnica Federico Santa Maria, Chile

This paper presents performance limitations in the control of single-input linear time-invariant (LTI) plants when controlled over a fading channel. Our main result is a closed form characterization of the minimal stationary plant output variance, as an explicit function of channel statistics and plant characteristics. To derive our results, we first show that there exists an equivalence, in a second order moment sense, between a fading channel and an additive white noise channel subject to a stationary SNR constraint. Such equivalence is then exploited to state conditions for stabilization, and to derive explicit performance limitations, as immediate corollaries of known results in the literature on networked control subject to SNR constraints.

Explicit Conditions for Stabilization over Noisy Channels Subject to SNR Constraints
Francisco J. Vargas1, Eduardo I. Silva1, Jie Chen1
1Universidad Técnica Federico Santa Maria, Chile; 2City University of Hong Kong, Hong Kong

In this paper, we analyze the stability of networked control systems when parallel additive white noise (AWN) channels are considered. We assume that the parallel AWN channels are individually constrained in its signal to noise ratio (SNR). We obtain explicit conditions on the minimum requirements on the channel SNRs necessary for stability for a set of particular plant structures. Our results show explicitly the role played by the unstable plant pole directions in the stability of NCSs. We also show that, when state feedback control is used, a simple characterization on the channel SNRs for stability can be given.

Performance Evaluation of Non-Minimum Phase Linear Control Systems with Fractional Order Partial Pole-Zero Cancellation
Nazli Khalili Zadeh Mahani1, Ali Khaki Sedigh2, Farshad Merrikh Bayat3
1Islamic Azad University South Tehran Branch, Iran; 2K.N.Toosi University of Technology, Iran; 3University of Zanjan, Iran

It has been known that, real right half plane (RHP) zeros imply serious limitations on the performance of non-minimum phase systems. Feedback cannot remove these limitations, mainly because RHP zeros cannot be cancelled by unstable poles of the controller since such a cancellation leads to internal instability. Hence, the idea of using fractional order systems in partial cancellation of the RHP zeros without leading to internal instability is studied. In this paper, the partial cancellation of RHP zeros with RHP poles is proposed using the fractional calculus approach. It is shown that undershoot and settling time of the compensated system is improved. Using suitable optimum criterion, it is shown that the performance of closed loop system can be relatively improved. Simulation results are used to show the effectiveness of the proposed methodology.

Leader-Following Consensus Control for Markovian Switching Multi-agent Systems with Interval Time-Varying Delays
Myeongjin Park1, OhMin Kwon1, Ju Hyun Park2, Sang Moon Lee1, Eun Jong Cha1, Tae Hee Lee2
1Chungbuk National University, South Korea; 2Yeungnam University, South Korea; 3Daegu University, South Korea

This paper considers multi-agent systems with interval time-varying delays and Markovian switching interconnection topology. By construction of a suitable Lyapunov- Krasovskii functional and utilization of reciprocally convex approach, new delay-dependent consensus analysis and control for the systems are established in terms of linear matrix inequalities (LMIs) which can be easily solved by various effective optimization algorithms. One numerical example is given to illustrate the effectiveness of the proposed methods.

Constructing Hyperchaotic Systems with Multiple Positive Lyapunov Exponents
Chaowen Shen1, Simin Yu1, Jinhu Lu1, Guanrong Chen1
1Guangdong University of Technology, China; 2Chinese Academy of Sciences, China; 3City University of Hong Kong, Hong Kong

This paper introduces a novel approach for generating continuous-time autonomous hyperchaotic systems with multiple positive Lyapunov exponents. In particular, this paper develops two general design principles for constructing various hyperchaotic systems with desired numbers of positive Lyapunov exponents. Two typical examples are then given to verify the proposed design principle. In particular, the developed method can design hyperchaotic systems with any multiple positive Lyapunov exponents by following a unified procedure compared with the traditional trial-and-error approach.
**Self-Tuning Dynamic Matrix Control of Two-Axis Autopilot For Small Aeroplanes**

Drago Matko\(^1\), Tine Tomazic\(^2\), Matija Arh\(^2\), Igor Skrjanc\(^2\)

\(^1\)University of Ljubljana, Slovenia; \(^2\)Pipistrel d.o.o., Slovenia

An easy-to-implement method of self-tuning of 2-axis autopilot parameters using Dynamic Matrix Control (DMC) is presented. Based on step responses caused by a hysteresis relay feedback from roll/pitch angles, the inner (angular velocity) loop controllers are designed. Applying the step responses of the inner loop, the same method is used to design the outer (roll/pitch angle) controllers. Then the airspeed/vertical-speed controller is designed by recording the step responses to changes of thrust and pitch angle using the multivariable (2x2) DMC controller design method. Finally the directional (heading) and altitude control can be achieved by a simple controller. The simulations of an extremely sensitive (in pitch) and marginally stable airplane demonstrate the applicability of the method and confirm that the proposed system can perform advanced functions, which surpasses conventional 2-axis autopilots commonly used in light airplanes or UAVs by far, without increasing the complexity of the controller part.

**Pitch/Yaw Momentum Position Control of Roll Momentum Biased Satellite System**

Kyoung-Hyun Oh, Hae-Yeong Gwon

Dong-A University, South Korea

In this paper, we utilize the roll momentum bias to control the pitch/yaw attitude of the satellite. While the previous control approaches have used the PD control approach, we design a new PID controller in order to improve the transient response over the existing methods. Through the example, we show that our control approach indeed improves the control performance over the existing results. For simulation, the system parameters are taken from the values of KOREASAT1.

**A Guidance Strategy for Multi-player Pursuit and Evasion Game in Maneuvering Target Interception**

Ting-Kuo Wang, Li-Chen Fu

National Taiwan University, Taiwan

To raise the probability of destroy maneuvering target (eg. ballistic missile), the idea of multi-missiles interception is proposed in this paper. Each one of the intercepting missile is equipped with the IR Image seeker which can provide excellent stealth ability during its course of tracking the ballistic missile. The intelligent ranging system integrates the Interacting Multiple Model (IMM) technique and the concept of reachable set to find the optimal results by minimize the energy of pursuing the targets. The guidance law of missile interceptor is designed based on pursuit and evasion game theory while considering the motion of the target in 3-D space such that the distance between the missiles and the target is minimized. Finally, various simulations are demonstrated to examine the performance of the proposed system.

**A Pseudospectral Approach to Ascent Trajectory Optimization for Hypersonic Air-Breathing Vehicles**

Wei Shi, Zhongliang Jing, Yongsheng Yang, Hui Ge

Shanghai Jiao Tong University, China

The objective of this paper is to investigate a reliable method to generate optimal ascent trajectory for hypersonic air-breathing vehicles. When solving optimal trajectories in endo-atmospheric flight, most of traditional indirect methods suffer from difficulties in finding an appropriate initial guess and getting a convergent solution for the two point boundary value problem (TPBVP). With improvements on on-board computer performance, direct methods such as pseudospectral method show promising potential for real-time optimal guidance. It removes the need for computing analytical gradients of aerodynamic coefficients, and remains high accurate solution similar to indirect methods. In this work, optimal ascent trajectory generation problem was formulated as a fuel-optimal control problem. Gauss pseudospectral method (GPM) was presented to generate the optimal ascent trajectories. Optimal solutions from GPM were compared with an indirect method based on finite difference method (FDM). Numerical simulations were studied with various initial conditions to investigate the optimal trajectory characteristics for hypersonic air-breathing vehicles. The results verified the validity and accuracy of GPM for ascent trajectory optimization.

**The Effect of Measurement for Time Synchronization Error in the Tightly Coupled GPS/INS Integration**

Cheol-Kwan Yang, Duk-Sun Shim

Chung-Ang University, South Korea

The performance of tightly coupled GPS/INS integration gets worse if the time synchronization error occurs between the GPS receiver and INS (Inertial Navigation System). The effect of measurement due to time synchronization error is investigated for tightly coupled GPS/INS integration. The measurement considered is pseudorange, or both pseudorange and pseudorange rate.
Caterpillar Mechanism for A Portable Haptic Interface of Endoscopy Simulation
Yunjin Gu, Doo Yong Lee
KAIST, South Korea
The current haptic interfaces for endoscopy simulation can be divided into two categories: the linear carriage systems and friction roller systems. Both types have natural drawbacks for a complete haptic interface of endoscopy simulation. This paper proposes a new mechanism which is not included in any of the current categories. The haptic interface consists of translational and rotational mechanisms. This paper focuses on the translational mechanism. Design constraints and optimization process of the mechanism are discussed including results of simulation and experiment.

Design of A Haptic Interface for Simulation of Needle Intervention
Seung Gyu Kang, Doo Yong Lee
KAIST, South Korea
Needle intervention is minimally invasive image guided procedures that diagnose and treat diseases using a needle. This paper proposes design of a haptic interface for a training simulation of the needle intervention. The design focus is on the 2 degrees of freedom parallel rotation mechanism which should have low inertia and meet geometric constraints to realize the actual procedures. The proposed design has 2 degrees of freedom with 6 passive joints. So each passive joint is a function of 2 active joints which are driven by motors. This relations between active and passive joints are calculated by kinematic analysis of the mechanism.

Hands Tracking with Self-occlusion Handling in Cluttered Environment
Bor-jeng Chen¹, Cheng-Ming Huang², An-Sheng Liu², Ting-En Tseng¹, Li-Chen Fu³
¹National Taiwan University, Taiwan; ²National Taipei University of Technology, Taiwan
This paper presents a two-hands tracking method with a monocular camera for human machine interaction (HMI). To clarify the face of the user and his/her hands, the face is also tracked in our method. The targets are tracked independently when they are far from each other; however, they are merged with dependent likelihood measurements in higher dimension while they are likely to interrupt each other. While one target is being tracked in the independent situation, other targets are masked to decrease the skin color disturbances on the tracked one. Multiple cues, including the combination of the locally discriminative color weighted image and the back-projection image of the reference color model, the motion history image and the gradient orientation feature, are employed to verify the hypotheses originated from the particle filter. On the other hand, when the targets are closing or even overlapping, the multiple importance sampling (MIS) particle filter generates the tracking hypotheses of the merged targets by the skin blob reasoning and the depth order estimation. These joint hypotheses are then evaluated by the visual cues of occluded face template, hand shape gradient orientation, motion continuity and forearm equation. The experimental results present the real-time efficiency and the robustness in comparison with the state-of-the-art human pose estimation method.

Development of Power Assist System with Motion Estimation Using Model Predictive Control
Takahiko Mori, Yuya Tanaka
Gifu National College of Technology, Japan
Many kinds of control methods using electromyogram signals have been proposed for power-assist robots or electric prostheses recently. However, it is considered that it is difficult to be adapted to unknown environment or conditions and to realize high power-assist ratio. Therefore, we propose a new power-assist system using model predictive control that can realize a stable power-assist with high ratio and predict the future human fingers touque and the future trajectory in real time. Our power-assist system is composed of a combination of a MPC system based on an expansion plant and a MPC system based on a plant model.

Classical and Subsequence Dynamic Time Warping for Recognition of Rigid Body Motion Trajectories
Ozkan Cigdem, Tinne De Laet, Joris De Schutter
KU Leuven, Belgium
In many robotic applications, the motions of a human and a robot are recognized by studying of their motion trajectories. Hence, motion trajectory recognition is important in human and robot movement analysis. In this paper, the recognition of six degrees-of-freedom rigid body motion trajectory of an object is studied. The three-dimensional measured position trajectories of LED markers attached to rigid body are transformed to the time-based invariant representation of the rigid body motion trajectories. The main objective of this paper is to evaluate the performance of classical and subsequence dynamic time warping algorithm on the recognition of the rigid body motion trajectories. The experimental results show that the use of the length of shortest warping path in the calculation of DTW distances is not significantly better than the use of only the length of model signal for the nine artificial motions used in experiments. However, the used method
promises to improve recognition of more complex everyday motions. Additionally, the results indicate that the classical DTW algorithm gives more meaningful results than subsequence DTW algorithm for the available recorded motions.

26th June, Wednesday
8:40 - 10:00 at Fevzi Cakmak
WeA5 Complex Systems and Networks (III)
Session Chair: Jinde Cao, Southeast University, China
Session Co-Chair: Min Meng, Shandong University, China

An Algebraic Approach to Hierarchical LQR Synthesis for Large-Scale Dynamical Systems
Daisuke Tsubakino¹, Taiki Yoshioka¹, Shinji Hara²
¹Hokkaido University, Japan; ²University of Tokyo, Japan
This paper considers an optimal hierarchical control problem for large-scale linear dynamical systems modeled by an interconnected system under multi-scale information exchange networks. We first propose an algebraic characterization of hierarchies by using semigroups and the Kronecker product. The multiplication rule of the Kronecker product quite fits to the property of semigroups. As a result, a condition under which the stabilizing solution of the Riccati equation inherits the hierarchy is obtained with the aid of the previous result. Furthermore, the proposed framework makes it possible to understand several previous results on decentralized optimal control from a unified viewpoint.

Controllability of Higher Order Switched Boolean Control Networks
Lequn Zhang, Jun-e Feng, Min Meng
Shandong University, China
This paper investigates controllability of higher order switched Boolean control networks (SBCNs). First, by using semi-tensor product (STP) method, two algebraic forms of higher order SBCNs are derived. And a necessary and sufficient condition of controllability for higher order SBCNs is obtained. Then based on the second algebraic form, the corresponding control and switching-law which drive a point to a given reachable point are designed. Finally, an illustrative example is given to show the validity of the main result.

State Estimation for Genetic Regulatory Networks with Time-varying Delay Using Stochastic Sampled-data
Tae Hee Lee¹, Myeongjin Park², OhMin Kwon³, Ju Hyun Park¹, Sang Moon Lee³
¹Yeungnam University, South Korea; ²Chungbuk National University, South Korea; ³Daegu University, South Korea
This paper considers genetic regulatory networks with time-varying delay. By construction of a suitable Lyapunov-Krasovskii functional and utilization of stochastic sampled-data, a delay-dependent state estimation for the concerned systems is established in terms of linear matrix inequalities (LMIs) which can be easily solved by various effective optimization algorithms. One numerical example is given to illustrate the effectiveness of the proposed method.

Consensus of Fractional-order Linear Systems
Chao Song¹, Jinde Cao¹
¹Southeast University, China; ²Nanjing Institute of Technology, China
This paper studies the consensus control problem for a group of fractional-order linear multi-agent systems (MAS) with directed interaction topology when the fractional order $\alpha$ satisfies $0<\alpha<2$, by transforming it into the stability of a set of matrices. Based on the stability theory of fractional-order system, some sufficient and necessary conditions are presented to ensure the consensus of MAS in terms of linear matrix inequalities, and the feedback matrix of the proposed protocol is also determined accordingly.

26th June, Wednesday
8:40 - 10:20 at Barbaros A
WeA6 Mechatronics (I)
Session Chair: David Lindr, Technical University of Liberec, Czech Republic
Session Co-Chair: David Lindr, Technical University of Liberec, Czech Republic

Micro Defect Detection in Solar Cell Wafer Based on Hybrid Illumination and Near-Infrared Optics
Gyung-bum Ki
Korea National University of Transportation, South Korea
In this paper, an defect detection system based on hybrid illumination and near-infrared optics, is developed for solar cell wafer. It consists of geometrical camera optics, hybrid illumination device(HID), near-infrared(NIR) camera optics, machinery and control system and algorithm of defect detection and software. Especially, illumination conditions in HID is determined for reliable defect detection. Optimum illumination conditions in the HID are found with contrast analysis of RGB LED image, based on design of experiment. As a result, various surface micro defects are accurately detected. It is shown that the developed defect detection system can accurately detect micro defects of solar cell wafer.
Feedback Control Method Based on Direct Servomechanism Speed Sensing and Processing to Reduce Residual Vibration

David Lindr, Pavel Rydlo
Technical University of Liberec, Czech Republic

This paper describes one of the functional methods for suppression a two-mass system residual vibration. These vibrations are evoked due to the torsion plasticity of the mechanism kinematics chain members and acting of large moment of inertia. The method is based on comparison of the actual speed signals sensed by means of both the PMSM inbuilt internal encoder and external encoder. The external encoder measures the actual speed at the servomechanism end member (burdened with vibrations). By means of processing these signals is generated the correction signal. This signal consequently meets the control structure again as a speed feedforward signal. First of all the method was tested by means of mathematical model numerical simulations in Matlab Simulink. Right after its functionality has been proven in simulations was consequently implemented into the existing cascade structure of standard servo control unit Siemens Sinamics S120 by means of so called DCC Chart engineering tool. The results of simulations as well as of the experiments made on the real system proved the ability of proposed method to effectively compensate the two-mass system torsional vibrations.

Force Observer-Based Control for a Rehabilitation Hand Exoskeleton System

Nirvana Popescu1, Decebal Popescu1, Mircea Ivanescu2, Dorin Popescu3, Cristian Vladu2, Ileana Vladu2
1University Politehnica Bucharest, Romania; 2University of Craiova, Romania

This paper is a component of a research project regarding the design and development of an Intelligent Haptic Robot-Glove for the rehabilitation of the patients that have a diagnosis of a cerebrovascular accident. In this paper, the control system for a rehabilitation hand exoskeleton is discussed. In order to avoid the complex problems given by a distributed sensor network, this paper treats the problem of the compliance force control by using observers: a velocity observer, a force observer and a disturbance observer. Two control solutions are discussed. First, the disturbance effects are eliminated by a cascade closed loop control with velocity and force observers. Then, a disturbance observer is used to compensate the compliance effects. The performance of the control systems is demonstrated by the simulation.

UMAY1: A Modular Humanoid Platform for Education and Rehabilitation of Children with Autism Spectrum Disorders

Pinar Boyraz, Bora Yigit, Okan Bicer
Istanbul Technical University, Turkey

In this paper, a humanoid platform comprising a 6DOF robotic head will be introduced with its concept design emphasizing its motion and cognitive capabilities. The focus of the research is to obtain an effective and modular humanoid robot platform which can be used in incremental rehabilitation and education of the children with autism spectrum disorders. Therefore, the first aim is determined to form a robotic head capable of visual interaction and human-like motion of the head and eyes, keeping a simple design in mind. After the mechanical design of the head is introduced, the kinematics and dynamics of the unique 3DOF neck mechanism is detailed. The active vision system on top of the neck structure having the remaining 3DOF has currently basic capabilities such as face and/or object detection and tracking. In addition, the active vision system is designed as a modular unit and a 3D vision capability can be turned on using a Kinect depth camera depending on the task or the operating mode of the robot.

Nonlinear Modal Space Decoupled Control of Flight Simulator Motion System

CF Yang, Zhiyong Qu, Li Xiang, JW Han
Harbin Institute of Technology, China

This paper presented a novel control scheme for electro-hydraulically driven flight simulator motion system, in order to reduce the effect of strongly coupling and improve the control performance of motion system. The mathematical models of flight simulator motion system are formulated, including mechanical system and electro-hydraulic system, using Kane approach and hydromechanics principle. The uncoupled space is exploited for flight simulator motion system by singular value decomposition of inertial matrix. An effective modal control is developed with the feedback of dynamic modal actuator length in the uncoupled model space. Actually, a nonlinear modal decoupled control is designed for the flight simulator motion system with varied and coupling control gains. Theoretical analysis and simulation results show that the proposed control greatly reject the contribution of coupling and rather deplete the coupling error in work space for the flight simulator motion system, which exhibits excellent control performance.
LMI Based Model Order Reduction Considering the Minimum Phase Characteristic of the System
Gholamreza Khademi, Haniyeh Mohammadi, Maryam Dehghani
Shiraz University, Iran

One usual method to solve the model order reduction problem is to minimize the $H_{\infty}$-norm of the difference between the transfer function of the original system and the reduced one. In many papers, the minimization problem is solved using the Linear Matrix Inequality (LMI) approach. This paper deals with defining an extra matrix inequality constraint to guaranty that the minimum phase characteristic of the system preserves after order reduction. To achieve this goal, a special state-space realization of the system is introduced. The method applies to some sample example and the simulation results verify the performance of the proposed method.

Robust LQ Control with Adaptive Law for MIMO Descriptor System
Yusuke Watanabe, Naruya Katsurayama, Isao Takami, Gan Chen
Nanzan University, Japan

This paper presents a robust LQ control system with Model Reference Adaptive Control (MRAC) law for MIMO system which is described as descriptor form. Generally, the performance degradation is expected to happen in case that uncertainty excess the upper and lower bound which are considered in the robust control synthesis process. For this problems, adaptive control algorithms have potential to improve performance and reliability in control system. In this study, we focus on this characteristics of adaptive control algorithms and add adaptive law into usual robust control system. The proposed system is synthesized by two-step approach. First of all robust LQ controller is synthesized through solving some LMI conditions. This robust LQ controller can be handle with limited uncertainty parameters. Second, adaptive law is designed and consolidated closed loop stability of adaptive loop and the robust LQ control loop is analyzed though solving quadratic stability conditions. The feature of this study are as followings: 1. Quadratic stability is analyzed in case of MIMO system described as descriptor form with adaptive law. 2. Convergence speed is considered at the design process of adaptive law with $\sigma$-modification. 3. The effectiveness of the proposed method is verified by some experiments using a test-scale 2 Degree-of-Freedom (2DOF) helicopter.

H\_Infinity Loop Shaping for Positioning Control System with Nonlinear Friction
Yuki Sugiyama¹, Masakazu Nairo², Gan Chen², Isao Takami³
¹Mitsubishi Heavy Industries Ltd., Japan; ²Nanzan University, Japan

In this study, we propose a method of the positioning control for a ball screw system achieved by H infinity loop shaping. The H infinity controller is synthesized for friction compensation, zero steady error, and reference tracking performance by using weighting functions. A dynamic weighting function and a constant matrix are used for the loop shaping framework. The dynamic weighting function is selected for friction compensation and steady error. Frequency characteristics of friction is focused on in our approach. The frequency region where static friction and stick-slip motion appears predominantly is identified for choosing an appropriate dynamic weighting function. The other constant weighting matrix is selected to improve tracking performance. By considering the relationship between the loop shaping framework and LQ control framework, trial and error for choosing an appropriate weighting matrix is simplified. The effectiveness of the proposed method is verified by simulations with nonlinear friction and experiments.

Design and Application of Gain-Scheduling Control for A Hover: Parametric H\_\infty Loop Shaping Approach
Renan Pereira, Karl Heinz Kienitz
Instituto Tecnologico de Aeronautica, Brazil

This paper presents synthesis conditions for the design and application of Linear Parameter-Varying (LPV) controllers for a 3DOF (Degrees of Freedom) Hover. This laboratory plant simulates typical behaviors of an aircraft VTOL (“vertical taking-off landing”), also known as X4-flyer. The dynamics of the Hover are described by a 6th order model taking as state variables the angles of roll, pitch, yaw and associated rates. The design problem has been formulated via parametric H-infinity loop shaping control by describing the uncertainty as perturbations to normalized coprime factors of the shaped plant. The design strategy is characterized by the insertion of a free parameter that aims to increase the flexibility of the design ensuring robust stabilization of the linear parameter-varying system. For the existence of a gain-scheduled parametric H-infinity loop shaping controller, a set of sufficient conditions has been derived in an LMI framework. Finally, we present experimental results obtained with the application of the parametric H-infinity loop shaping controller for the tracking of reference trajectories of the Hover.
Improved Results on Frequency Weighted Optimal Hankel Norm Model Reductionm
Deepak Kumar1, S. K. Nagar2
1M. N. National Institute of Technology Allahabad, India; 2IIT (BHU) Varanasi, India
In this paper a new frequency weighted optimal Hankel norm model reduction algorithm is proposed which is based on a combination of Wang et al’s technique [14] and Varga and Anderson’s technique [13]. The proposed algorithm results stable reduced order models with both single sided and double sided weightings. A numerical example is considered to validate the proposed algorithm and the comparison with other well known techniques shows the effectiveness of the proposed algorithm.

26th June, Wednesday
10:40-12:20 at Inonu
WeB1 Complex Mechatronic Systems
Session Chair : Erdal Kayacan, University of Leuven, Belgium
Session Co-Chair: Peter Vrancx, Vrije Universiteit Brussel, Belgium
Session Co-Chair: Wouter Saeys, University of Leuven, Belgium

Model-Free and Model-Based Time-Optimal Control of A Badminton Robot
Melody Liu1, Bruno Depraetere2, Greg Pinte3, Ivo Grondman3, Robert Babuska4
1Deft University of Technology, the Netherlands; 2Flanders’ Mechatronics Technology Centre, Belgium
In this research, time optimal control is considered for the hit motion of a badminton robot during a serve operation. For this task the racket always starts at rest in a given position and has to move to a target state, defined by a target position and a non-zero target velocity. The goal is to complete this motion in as little time as possible, yet without violating bounds on the actuator. To find controllers satisfying these requirements, a reinforcement learning approach is implemented, using a Natural Actor-Critic (NAC) reinforcement learning algorithm. This approach is experimentally shown to yield the desired robot motions after about 200 trials. Next to this model-free learning approach, the control signals obtained with a model-based optimization are also applied to the robot. The results achieved with both approaches are compared, and a thorough analysis is presented, highlighting the properties of each approach, as well as their advantages and drawbacks.

Implementation of a Fractional PD Controller Tuned by Genetic Algorithm for A Steward Platform
Yu Zhong, Abhishek Dutta, Cosmin Copot, Clara Mihaela Ionescu. Robin De Keyser
Ghent University, Belgium
Mechatronic systems are conventionally modeled by integer order state equations for simplicity. Based on these integer-order models, integer-order PID or other classical model-based controllers are designed. However, often complex mechatronic systems require fractional-order state equations for a more adequate description. In this paper, a Steward platform (ball and plate system) with different balls is used to demonstrate this. A fractional-order PD controller is designed and tuned by a genetic algorithm based global optimizer to obtain the suitable parameter values in time domain. The experimental results show that the fractional-order PD controllers can provide better performances than conventional integer-order PD controllers.

Stabilizing Multiple Sliding Surface Control of Quad-rotor Rotorcraft
Nikola Shakev1, Andon Topalov2, Kostadin Shiev1, Okyay Kaynak2
1Technical University of Sofia, Bulgaria; 2Bogazici University, Turkey
The interest into the unmanned aerial vehicles (UAVs) has largely increased recently. With the advances in technologies it has become possible to test efficiently and cost-effectively different autonomous flight control concepts using small-scale aircrafts. In this paper the stabilizing control problem of quad-rotor rotorcraft using multiple sliding surface (MSS) controllers has been investigated. The ability of the MSS control approach to stabilize under-actuated systems and to deal with existing nonlinear mismatched uncertainties in the dynamic model makes it a suitable choice for controlling roll and pitch angles of the rotorcraft. The proposed method is based on the definition of multiple switching surfaces that define certain relationships between variables to be maintained after the system passes into a sliding mode. Its effectiveness on the stabilizing control of the rotorcraft is demonstrated by the results obtained from flight simulations with an accurate dynamic model of the Dragonflyer V Ti four-rotor miniature helicopter.

Model-Free Learning of Wire Winding Control
Abdel Rodriguez1, Peter Vrancx2, Ann Nowe1, Erik Hostens2
1Vrije Universiteit Brussel, Belgium; 2Flanders’ Mechatronics Technology Centre, Belgium
In this paper we introduce a reinforcement learning approach to optimize the wire profile generated by an automated wire winding machine. The wire winder spools wire onto large bobbins, while trying to maintain an even wire profile across the bobbin. Uneven profiles can contain bumps or gaps (i.e. areas with too much or too little wire) lead to snagged or breaking wires when the bobbin is unwound. By setting the turning points of the traversal system which distributes the wire over a spinning bobbin, a controller can influence the amount of wire spoiled on the edges of the bobbin. The behavior of the wire, however, is highly non-deterministic and extremely difficult to model with sufficient accuracy, making the application of a model based controller technique difficult. This fact makes reinforcement learning a promising approach to apply, as
this technique can learn optimal policies relying only on interactions with the plant. We apply a learning algorithm called continuous reinforcement learning automata and empirically demonstrate that this technique can successfully optimize the wire profile, even on rounded bobbins that require continuous adaptation of the turning point.

**On On-Line Sampled-data Optimal Learning for Dynamic Systems with Uncertainties**

Shou-Han Zhou¹, Ying Tan², Denny Oetomo³, Christopher Freeman⁴, Iven Mareels¹

¹University of Melbourne, Australia; ²University of Southampton, UK

In this study, a novel on-line optimal learning control is proposed to achieve the optimal performance for dynamic systems with modeling uncertainties, measurement noise and iteration-varying initial conditions. By introducing a nominal model and a sampled-data controller, it is possible to find the optimal solution iteratively of an optimization problem using gradient descent method. A feedback controller is introduced along the finite-time domain to ensure that the difference between the output of the nominal model and that of the actual plant can be made arbitrarily small. This feedback can be used to handle various uncertainties in the plant model, while the feedforward learning controller is used to ensure the convergence of the plant output to the optimal solution. Hence, by tuning sampling period and feedback gain matrix, it is possible to ensure that the output of plant converges semi-globally practically to the optimal solution. Simulation results illustrate the effectiveness of the proposed method.

**26th June, Wednesday**

10:40-12:40 at Malazgirt 1

**Web2** Robotics and Motion Control (V)

**Session Chair:** Min Tan, Chinese Academy of Sciences, China

**Session Co-Chair:** Selim Ozel, Sabanci University, Turkey

**Humanoid Robot Orientation Stabilization by Shoulder Joint Motion During Locomotion**

Selim Ozel, Sefik Emre Eskimez, Kemalettin Erbatur

Sabanci University, Turkey

Arm swing action is a natural phenomenon that emerges in biped locomotion. A shoulder torque reference generation method is introduced in this paper to utilize arms of a humanoid robot during locomotion. Main idea of the technique is the employment of shoulder joint actuation torques in order to stabilize body orientation. The reference torques are computed by a method which utilizes proportional and derivative actions. Body orientation angles serve as the inputs of this system. The approach is tested via simulations with the 3D full-dynamics model of the humanoid robot SURALP (Sabanci University Robotics Research Laboratory Platform). Results indicate that the method is successful in reducing oscillations of body angles during bipedal walking.

**Shop-floor Controller Based on RT-Middleware Technology**

Ferenc Tajti¹,², Geza Szayer³, Bence Kovac⁴, Peter Korondi³

¹Budapest University of Technology and Economics, Hungary; ²MTA-ELTE Comparative Ethological Research Group, Hungary

**Abstract—** Nowadays the flexible configuration of manufacturing cells becomes to an important requirement especially at small and medium sized companies. This method can make the production fast and effective at small series or frequent manufacturing changes. The shop-floor control method – presented in this paper – offers a solution for the facing problem of fast and easy reconfiguration. The hardware of the controller designed modular with software components for online configuration. This solution allows sensor integration on different levels for every part of the manufacturing cell. With unified programming language and the machine specific controllers (post-processing) the cells can be defined easily by different types of human-machine interaction. The shop-floor control architecture is implemented and validated on an Adept SCARA robot. The robot is driven by standalone, low-level, interchangeable, software and hardware components.

**Adaptive Unstructured Road Detection Using Close Range Stereo Vision**

Kadri Bugra Ozutemiz, Akif Hacinecipoğlu, Bugra Koku, Erhan Ilhan Konukseven

Middle East Technical University, Turkey

Detection of road regions is not a trivial problem especially in unstructured and/or off-road domains since traversable regions of these environments do not have common properties unlike urban roads or highways. In this paper a novel unstructured road detection algorithm that can continuously learn the road region is proposed. The algorithm gathers close-range stereovision data and uses this information to estimate the long-range road region. The experiments show that the algorithm gives satisfactory results even under changing light conditions.

**A Trajectory Prediction Algorithm Based on Fuzzy Rectification for Spinning Ball**

Ren Yangqing, Zaojun Fang, De Xu, Min Tan

Institute of Automation, Chinese Academy of Sciences, China

Trajectory prediction plays a very important role in the process of playing table tennis for robot. Its accuracy determines whether the striking action will succeed or not. This paper first analyses how the spinning influences the flight model and
the rebound model for the flying table tennis. Two models are designed for spinning balls. Meantime, it indicates that the offset on y axis is related to the flight distance on x axis and rotation degree. Then a fuzzy controller is designed for online rectification of the trajectory. And a trajectory prediction algorithm is presented for the spinning ball combined with the algorithms based on the parameter model and experience learning. The experiment results validate the effectiveness of the proposed method.

**VF-RRT: Introducing Optimization into Randomized Motion Planning**

Inyoung Ko, Beobkyoon Kim, Frank Chongwoo Park  
Seoul National University, South Korea

The Vector Field Rapidly-exploring Random Tree (VF-RRT) algorithm is an extension of the RRT algorithm for planning in the presence of vector fields; its main distinguishing feature is that random nodes are generated in such a way that the trees tend to extend along the directions of the given vector field. By constructing vector fields to be aligned in the direction that minimizes the upstream cost, which is a new criterion for measuring the extent to which a path moves against the vector field flow, the VF-RRT algorithm can be used to efficiently generate nearly optimal paths while remaining with a probabilistic planning setting. Experimental results comparing our paths with those produced by the T-RRT algorithm and the basic RRT algorithm are presented.

**Experimental External Force Estimation Using a Non-Linear Observer for 6 axes Flexible-Joint Industrial Manipulators**

Jinna Qin, François Leonard, Gabriel Abba  
National Engineering College of Metz, France

This paper proposes a non-linear observer to estimate not only the state (position and velocity) of links but also the external forces exerted by the robot during Friction Stir Welding (FSW) processes. The difficulty of performing this process with a robot lies in its lack of rigidity. In order to ensure a better tracking performance, the data such as real positions, velocities of links and external forces are required. However, those variations are not always measured in most industrial robots. Therefore, in this study, an observer is proposed to reconstruct those necessary parameters by using only measurements of motor side. The proposed observer is carried out on a 6 DOF flexible joint industrial manipulator used in a FSW process.

**Control of Solid Oxide Fuel Cells: An Overview**

Marvin Leung¹, Gunhyung Park¹, Verica Radisavljevic-Gajic²  
¹Rutgers University, USA; ²Villanova University, USA

In this paper, the authors present an overview for control of solid oxide fuel cells. Even though a large amount of literature of SOFCs has been published in last decade, most of them has focused on electrochemical characteristics such as cell components, new materials, reaction mechanisms, etc. This paper goes through a review of control of SOFCs for last decade.

**Modeling, Control and Simulation of DFIG for Maximum Power Point Tracking**

Mahammad Sleiman¹,², Bachir Khedjar³, Abdelhamid Hamadi³, Kamal Al-Haddad³, Hadi Y. Kanaan²  
¹Lebanese University, Lebanon; ²Saint-Joseph University, Lebanon; ³Ecole de Technologie Superieure, Canada

This paper deals with the modeling, analysis, control and simulation of a doubly-fed induction generator (DFIG) driven by a wind turbine. This grid connected wind energy conversion system (WECS) is composed of DFIG and two back-to-back PWM voltage-source converters in the rotor circuit. A mathematical model of the machine, derived in an appropriate dq reference frame is established. The grid voltage oriented vector control is used for the grid side converter (GSC) in order to maintain a constant DC bus voltage and to compensate for reactive power at the power network. The stator voltage oriented vector control is adopted in the rotor side converter (RSC) control strategy, providing efficient handling of active and reactive power at the stator, as well as a maximum power point tracking (MPPT) method for the DFIG-based wind turbine. The proposed system is simulated for different operating conditions to illustrate the reliability of the control technique. Corresponding system simulation results under nonlinear load variations and wind speed transients are presented to demonstrate the significance of MPPT in WECS, and the effectiveness of adopted control technique.

**Energy Transfer Modeling of Thermoacoustic Engines with Boundary Resonant Control**

Boe-Shong Hong, Chia-Yu Chou, Tsu-Yu Lin  
National Chung Cheng University, Taiwan

This paper presents the thermoacoustic engines with internal heating of mean flow and external heat-excitation of acoustic vibration, which have much larger power ratings than conventional types. In the modelling, the conservation of
thermoacoustic storage is formulated to figure out engine cycles, capable of quantifying the effects of working gas and working frequency on power ratings, as well as shaping engine chamber adaptable to mechatronic load in power transmission. Moreover, this conservation law can be applied to identify through energy-loss measurement the parametric modelling upon flow leakage at the load end. Meanwhile, with the spatiotemporal transfer-function, the coupling of Rijke chamber dynamics and load dynamics is represented by feedback interconnection, which transforms the overall design into a feedback system. Based on such an internal feedback construction, digital signal processing is implemented to do numerical calculations on engine cycles with different frequencies of excitation.

Prediction of Building Lighting Energy Consumption Based on Support Vector Regression  
Dandan Liu¹,², Qijun Chen¹  
¹Tongji University, China; ²Shanghai University of Electric Power, China  
Prediction of energy consumption is an important task in energy conservation. Due to support vector regression has good performance in dealing with non-linear data regression problem, in recent years it often was used to predict building energy consumption. Based on the historical data we conclude the relationship between lighting energy consumption and its influencing factors is non-linear. To develop accurate prediction model of lighting energy consumption, the support vector regression with radial basis function was applied. The forecast results indicate that the prediction accuracy of support vector regression is higher than neural networks. The prediction model can forecast the building hourly energy consumption and assess the impact of office building energy management plans.

Open-Loop Nash Equilibrium Problem in Polynomial Stochastic Differential Games with Incomplete Information  
Manuel Jimenez-Lizarraga, Michael Basin, Celeste Rodriguez, Pablo Rodriguez-Ramirez  
Autonomous University of Nuevo Leon, Mexico  
This paper presents a near-equilibrium solution to the problem of finding open-loop Nash strategies for a stochastic polynomial differential game with incomplete information and over linear observations. Each player has a linear-quadratic cost as the individual performance index. The proposed strategy design is based on the so-called State-Dependent Riccati Equations and works effectively as is shown in a simulation example.

Input-Output Finite-Time Stability of Positive Switched Linear Systems with State Delays  
Shipei Huang¹, Hamid Reza Karimi², Zhengrong Xiang³  
¹Nanjing University of Science and Technology, China; ²University of Agder, Norway  
This paper is concerned with the problem of input-output finite-time stability (IO-FTS) for a class of discrete-time positive switched systems with time-varying delays. Two sufficient conditions for the existence of IO-FTS of such systems with respect to two different input signals are presented, respectively. All the results obtained are formulated in a set of linear inequalities. Two numerical examples are given to illustrate the effectiveness of the proposed results.

A Super-Twisting Algorithm for Systems of Relative Degree More Than One  
Michael Basin, Pablo Rodriguez-Ramirez  
Autonomous University of Nuevo Leon, Mexico  
This paper presents a homogeneous continuous super-twisting algorithm for systems with relative degree more than one. The conditions of finite-time convergence to an equilibrium are obtained demonstrating that the equilibrium can be moved as close to the origin as necessary, increasing a value of the control gain. The paper concludes with numerical simulations illustrating performance of the designed algorithms.

Mean-Square Filtering Problem for Stochastic Polynomial Systems with Gaussian and Poisson Noises  
Michael Basin, Pablo Rodriguez-Ramirez  
Autonomous University of Nuevo Leon, Mexico  
This paper presents the mean-square finite-dimensional filter for polynomial system states confused with both, Gaussian and Poisson, white noises over linear observations. Designing the mean-square filter for polynomial systems with white Gaussian and Poisson noises enables one to address the mean-square filtering problems for nonlinear system states confused not only with Gaussian white noises but arbitrary strictly defined white noises being weak mean-square derivatives of martingales. A procedure is established for designing the optimal filtering equations for system states described by polynomial equations of an arbitrary finite degree. An explicit closed form of the designed filter is obtained in case of a third-order polynomial. Performance of the designed optimal filter is verified for a third degree polynomial state.
H_\text{Infinity} Controller Design for the Synchronization of a Hyper-Chaotic System
Hamid Reza Karimi, Peng Shi, Bo Wang
1University of Agder, Norway; 2The University of Adelaide, Australia; 3Victoria University, Australia; 4Xinhua University, China; 5University electronic Science and Technology of China, China

In this paper, the robust control on the synchronization of a hyper-chaotic system is investigated. Based on Lyapunov stability theory and linear matrix inequality techniques, the multi-dimensional and the single-dimensional robust H\text{\text{Infinity}} synchronization controllers are constructed for the possible application in practical engineering. Some numerical simulations are provided to demonstrate the effectiveness of the presented controllers.

Chaos Synchronization for a Class of Chaotic Systems via H\_\text{\text{Infinity}} Control Technique
Peng Shi, Hamid Reza Karimi, Bo Wang
1The University of Adelaide, Australia; 2Victoria University, Australia; 3University of Agder, Norway; 4Xinhua University, China; 5University electronic Science and Technology of China, China

In this paper, the robust synchronization control for a class of chaotic systems is studied. Based on linear matrix inequality techniques and Lyapunov stability theory, a novel H\text{\text{Infinity}} robust synchronization controller is designed for the possible application in real engineering. Finally, some numerical simulations are included to demonstrate the effectiveness of the proposed techniques.

Central Energy-to-Peak Filter Design for Linear Systems
Michael Basin, Manuel Serna, Pedro Ivan Lopez-Hernandez
Autonomous University of Nuevo Leon, Mexico

This paper presents the central finite-dimensional energy-to-peak filter for linear systems that is optimal with respect to a modified Bolza-Meyer quadratic criterion including the first degree state-dependent term and the attenuation control term with the opposite sign. The obtained solution is based on reducing the original energy-to-peak filtering problem to the corresponding mean-module filtering problem. The paper first presents the central energy-to-peak filter for linear systems, based on the optimal mean-module filter, assuming the standard filtering conditions of stabilizability, detectability, and noise orthonormality. Finally, to relax the standard conditions, the paper presents the generalized version of the designed energy-to-peak filter in the absence of the noise orthonormality. Numerical simulations are conducted to verify performance of the designed energy-to-peak filter for linear systems against the central suboptimal H\text{\text{Infinity}} filter. The simulation results show a definite advantage in the values of the noise-output energy-to-peak norm in favor of the designed filter.

A Fault-Tolerant Control Scheme for a Hovering Underwater Vehicle subject to Region Function Formulation
Zool Ismail, Ahmad Athif Mohd Faudzi, Matthew Dunnigan
1University teknologi Malaysia, Malaysia; 2Heriot-Watt University, UK

This paper presents a new technique to control a hovering Autonomous Underwater Vehicle (AUV) mounted with four horizontal and four vertical thrusters. In this control scheme, fault tolerant decomposition and region based control schemes for tracking purposes are used. A Lyapunov-like function is presented for convergence analysis of the proposed control law. Based on numerical simulations, the performance of conventional tracking control and the proposed technique is presented concerning two cases: the first case is with no thruster faults and the second case is where any one of the four horizontal thrusters is faulty and any one of the four vertical thrusters is faulty.

Adaptive Kernel Principal Component Analysis for Nonlinear Dynamic Process Monitoring
Chakour Chouaib, Harkat Mohamed-Fauzi, Djeghaba Messaoud
Badji Mokhtar Annaba University, Algeria

In this paper a new algorithms for adaptive kernel principal component analysis (AKPCA) is proposed for dynamic process monitoring. The proposed AKPCA algorithm combine two existing algorithm, the recursive weighted PCA (RWPCA) and the moving window kernel PCA algorithms. For fault detection and isolation, a set of structured residuals is generated by using a partial AKPCA models. Each partial AKPCA model is performed on subsets of variables. The structured residuals are utilized in composing an isolation scheme, according to a properly designed incidence matrix. The results for applying this algorithm on the nonlinear time varying processes of the Tennessee Eastman shows its feasibility and advantageous performances.
A Statistical Fault Detection Strategy using PCA Based EWMA Control Schemes
Fouzi Harrou, Mohamed Nounou, Hazem Nounou
Texas A&M University at Qatar, Qatar
In data-based method for fault detection, principal component analysis (PCA) has been used successfully for fault detection
in system with highly correlated variables. The aim of this paper is to combine the exponentially weighted moving average
(EWMA) control scheme with PCA model in order to improve fault detection performance. In fact, PCA is used to provide a
modeling framework for the develop fault detection algorithm. Because of the ability of EWMA control scheme for
detecting small changes, this technique is appropriate to improve the detection of a small fault in PCA model. The
performance of the PCA-based EWMA fault detection algorithm is illustrated and compared to conventional fault detection
methods using simulated continuously stirred tank reactor (CSTR) data. The results show the effectiveness of the developed
algorithm.

Approximation of a Thermal Diffusive Interface Fractional-Order System – Part 1: Application to A Semi-Infinite Plan
Roy Abi Zeid Daou¹, Fady Christophy²*, Riad Assaf¹, Xavier Moreau¹
¹Lebanese German University, Lebanon; ²University of Bordeaux I, France
The fractional differentiation and integration exist in natural phenomena or can be artificially introduced into other
domains. Concerning the thermal diffusive interface, the fractional expression is emphasized when taking the applied flux
as input for the system and the measured temperature at any point as an output. However, the main problem when facing
such systems is to pass from the frequency domain to the time domain in order to estimate the response of the system at
any point for any input at any instance. So, the aim of this work is to present a method to approximate the fractional
system that models the semi-infinite plane medium. The second part of this work presents the approximation of a finite
plane medium. The results show that the approximation leads to very good behaviour.

Approximation of A Thermal Diffusive Interface Fractional-Order System – Part 2: Application to A Finite Plane
Fady Christophy¹*, Roy Abi Zeid Daou¹, Riad Assaf¹*, Xavier Moreau¹
¹Lebanese German University, Lebanon; ²University of Bordeaux I, France
As in the first part, the main purpose of this work is to derive some models used to the design and the validation of an
automatic control system of temperature. After presenting, in the first part, the modelling and the approximation of the
diffusive interface in the homogeneous semi-infinite plane medium, this second part deals with homogeneous finite plane
medium. From partial differential equations that govern one-dimensional heat transfer, the transfer function of the
medium is first computed considering the boundary conditions and the initial time temperature value. As for the
semi-infinite plane medium, the fractional integrator of order 0.5 appears. However, for this case, it shows up for a limited
frequency range. Then, a condition that permits to consider a finite medium as a semi-infinite medium around the
crossover frequency of the control loop is proposed. If this condition is respected, then the method presented in the first
part to approximate the fractional model by a rational model can be used to time simulation.

Robust Smoothing for Discrete-Time Uncertain Nonlinear Systems
Abhijit Kallapur, Ian Petersen
University of New South Wales, Australia
This paper derives recursion equations for a robust smoothing problem for a class of nonlinear systems with uncertainties
in modeling and exogenous noise sources. The systems considered operate in discrete-time and the uncertainties are
modeled in terms of a sum quadratic constraint. The robust smoothing problem is solved in terms of a forward-time and a
reverse-time filter. Both these filters are formulated in terms of set-valued state estimators and are recast into subsidiary
optimal control problems. These optimal control problems are described in terms of discrete-time Hamilton-Jacobi-Bellman
equations, whose approximate solutions lead to recursive Riccati difference equations, filter state equations, and level shift
calar equations for the forward-time and the reverse-time filters.

Low-Complexity MISO Models of T1DM Glucose Metabolism
Marzia Cescon¹, Rolf Johansson², Eric Renard¹
¹Lund University, Sweden; ²University Hospital and University of Montpellier, France
One of the main limiting factor in developing a control algorithm for glycemia regulation is the lack of a control-oriented,
parsimonious yet physiologically sound and individualized model able to reflect the basic dynamical features of the
glucose-insulin metabolic system required for the control design. In this paper we focus on estimating low-complexity MISO
models of the glucose metabolism in T1DM developed specifically for a controller implementing a basal-bolus therapy. The
models are continuous-time second-order transfer functions relating the amount of carbohydrate of a meal and the insulin
dose administered accordingly (inputs) to plasma glucose evolution (output) and consist of 4 parameters clinically relevant to be identified.

**Simple Virtual Slip Force Sensor for Walking Biped Robots**
Iyad Hashlamon, Kemalettin Erbatur
Sabanci University, Turkey

This paper presents a novel simple Virtual Slip Force Sensor (VSFS) for a walking biped. Bipeds walking stability is critical and they tend to lose it easily in real environments. Among the significant aspects that affect the stability is the availability of the required friction force which is necessary for the robot not to slip. In this paper we propose the use of the virtual sensor to detect the slip force. The design structure of the VSFS consists of two steps, in the first step it utilizes the measured acceleration of the center of mass (CoM) and the ZMP signals in the simple linear inverted pendulum model (LIPM) to estimate the position of the CoM, and in the second step the Newton law is employed to find the total ground reaction force (GRF) for each leg based on the position of CoM. Then both the estimated force and the measured force from the sensors assembled at the foot are used to detect the slip force. The validity of the proposed estimation method was confirmed by simulations on 3D dynamics model of the humanoid robot SURALP while walking. The results are promising and prove themselves well.

**Robust State Estimation via the Descriptor Kalman Filtering Method**
Chien-Shu Hsieh
Ta Hwa University of Science and Technology, Taiwan

This paper considers robust state estimation problem for uncertain descriptor systems subject to bounded uncertainties on the basis of the descriptor Kalman filtering (DKF) method. A new robust filtering framework (RFF), which divides the uncertain augmented output equation (AOE) into two parts: one is the nominal part and the other is the uncertain part, is proposed to facilitate the robust filter design. In the sequel, a robust descriptor Kalman filter (RDKF) is derived based on the proposed RFF and the DKF method. Some simplified versions of the RDKF are also proposed for special cases. The motivation of this research is to show that the AOE reformulation imbedded in the recursive ML estimation method serves as a useful mean to yield the dedicated robust filters. An extension of the proposed result to solve state estimation for uncertain descriptor systems with unknown inputs is also provided.

**Modeling and Identification of the Yaw Dynamics of an Autonomous Tractor**
Erkan Kayacan, Erdal Kayacan, Herman Ramon, Wouter Saëys
University of Leuven (KU Leuven), Belgium

This study deals with the yaw dynamics modeling and identification of an autonomous tractor. First, three different yaw dynamics models are developed considering various types of soil conditions. In these model derivations, the relaxation length is considered to calculate the tire side-slip angles for the two models, and the linear model is used to calculate the lateral forces on the tires for all the models. Then, to determine the most appropriate model for the autonomous tractor at hand, frequency domain identification method is preferred. After checking the level of nonlinearities of the steering mechanism and the yaw dynamics by using an odd-odd multisine signal as the excitation, these systems are identified by using maximum likelihood frequency domain identification method. The identifications results show that the two derived models among the three different models have the ability of identifying the yaw dynamics accurately. As a simpler model, an empirical second order model gives also reasonable identification results for the tractor at hand.

**System Stabilization by Unsymmetrical Saturated State Feedback Control**
Mohamed Benhayoun¹, Abdellah Benzaouia², Fouad Mesquine³, Ahmed EL Hajjaji⁴
¹University Cadi Ayyad, Morocco; ²Universite de Picardie, France

This paper studies the problem of linear unsymmetrical saturated systems. A new transformation for the unsymmetrical saturated linear problem control is presented to deal with the asymmetry of saturations under LMI form by using the available results on symmetrical saturation. These results are obtained for the first time reducing considerably the conservatism of the results obtained with symmetrical saturations. A numerical example is presented to illustrate the new results.

**Rejection of Sinusoidal Disturbances with Time Varying Frequency for Discrete Multivariable Systems: Adaptive Control with Q-Parametrization**
Dehri Khadija, Ltaief Majda, Nouri Ahmed Said
University of Gabes, Tunisia
In this paper, we propose a new adaptive control law with Q-parametrization for discrete multi-input multi-output systems subjected to sinusoidal disturbances with time-varying frequency. The rejection of sinusoidal disturbances with known frequency is obtained using partial state reference model control with Youla-Kucera parametrization. However, the frequency of these disturbances can be unknown and/or varying in time. The proposed solution is to estimate on-line the frequency of disturbances and then to adjust the controllers parameters. The simulation results are satisfactory and show good performances in terms of tracking reference trajectories and of rejecting sinusoidal disturbances with time varying frequency.

New Results for Feedback Control of Discrete Systems with Time Scales
Magdi S. Mahmoud
King Fahd University of Petroleum and Minerals, Saudi Arabia
The feedback control design problem for a wide class of discrete-time systems possessing fast and slow modes is considered in this paper. The slow and fast subsystems are considered to be completely controllable and observable. Based on the $\mathcal{H}_\infty$ optimization criteria, a two-stage design procedure is developed using separate gain matrices for the fast and slow subsystems and computed using linear matrix inequalities. A composite control is designed to yield first-order approximations to the behavior of the discrete system. Typical applications models are utilized to illustrate the design procedure and the simulation results validated the theoretical analysis.
Artificial Intelligent Control for Indoor Lighting Basing on Person Number in Classroom
Yifei Chen, Qian Sun
China Agricultural University, China
Comfortable lighting in classroom can promote the better learning environment. Today, owner of school not only provides a stimulating environment where student will learn best, and but they must concern the energy saving. For the lighting control and energy saving in classroom, the new method of intelligent control lighting based on using artificial intelligent algorithm is presented in this paper. Based on the number of students entering classroom, the lighting can be intelligent controlled to work by artificial neural network which is used for control head of this system, and the frame of control system is presented, and paper discussed the model of artificial neural network control with MIMO. After simulation, the conclusion has gotten that the characteristic of control network meets for the request with ability of self-study and self-adaption, and the function of automatic adjusting indoor lighting depending on the persons number has been achieved.

Adaptive Discrete-time Control with Dual Neural Networks for HFV via Back-stepping
Jianxin Ren, Xingmei Zhao, Bin Xu
Northwestern Polytechnical University, China
The article investigates the discrete-time controller for the longitudinal dynamics of the hypersonic flight vehicle. Based on the analysis of the control inputs, the dynamics model can be decomposed into the altitude subsystem and the velocity subsystem. Using the first-order Taylor expansion, the altitude subsystem can be transformed into discrete-time model, and then the strict-feedback form can be obtained. The controller is designed via back-stepping method. During this progress, neural networks are employed to approximate the mismatched uncertainties. Neural networks are used on the denominator of the controller as well as on the numerator of the controller to approximate the whole uncertainty (including the nominal value). The dual neural network controller via back-stepping is able to track system instructions accurately. Stability analysis proves that the errors of all the signals in the system are of uniform ultimate bound-ness. The simulation results show the effectiveness of the proposed controller.

Learning and Information for Dual Control
Tansu Alpcan, Iman Shames, Michael Cantoni, Girish Nair
University of Melbourne, Australia
In dual control problems, the aim is to concurrently learn and control an unknown system. However, actively learning the system conflicts directly with any given control objective as it involves disturbing the system for exploration. This paper presents a multi-objective approach to dual control, which explicitly quantifies both the learning and control objectives. Mutual information and relative entropy from information theory are used to quantify the information gain in active learning as part of the exploration process. The information gain is then balanced against a standard control objective. The presented approach is illustrated using Gaussian process regression, which provides a framework for learning nonlinear systems and is used as a demonstrative example. It is shown that the derived information measures are closely related to the variance of the predictive Gaussian distribution estimating the system.

Design and Evaluation of Motion Path for Specific Muscle Strengthening Using Neural Network
Kenta Itokazu, Takanori Miyoshi, Kazuhiko Terashima
Toyohashi University of Technology, Japan
In this paper, we propose algorithms of design for a motion path that is capable of strengthening specific muscles. By using the proposed algorithm, it is possible to design a motion path maximizing the activity of an agonist muscle and minimizing the activity of other muscles. EMG signal is measured during a trainig experiment and the degree of muscular revitalization is evaluated by the amplitude of EMG signal. Finally, the effectiveness of proposed approach is demonstrated through experiments.
Humanoid Robot Navigation and Obstacle Avoidance in Unknown Environments
Griswold Brooks, Prashanth Krishnamurthy, Farshad Khorrami
Polytechnic Institute of NYU, USA

In this paper, the problem of humanoid robot navigation in an unknown environment is considered. A path planning and obstacle avoidance system based on the GODZILA algorithm is proposed. The proposed approach is computationally very light-weight and does not require building of an environment map. The algorithm follows a purely local approach based on measurements from a pair of ultrasonic sensors (sonars) mounted on the robot. A primary challenge in the implementation of the path planning and obstacle avoidance system is the limited spatial information that is available due to the wide beam angle of the sensors. However, it is seen in simulation and experimental studies in this paper that a light-weight path planning and obstacle avoidance can be implemented with these ultrasonic sensors. Also, it is shown that the spatial uncertainty inherent in these sensors can be addressed through introduction of virtual sensors based on the beam angle; this concept of virtual sensors fits nicely within the GODZILA framework that is formulated based on range measurements from an arbitrary set of sensing directions, which in this implementation, is comprised of actual sensor directions and the virtual sensor directions. The performance of the proposed algorithm is demonstrated through simulations and experimental studies utilizing a NAO humanoid robot.

Influence of Frictions on Gait optimization of a Biped Robot with an Anthropomorphic Knee
Mathieu Hobon¹, Nafissa Lakbakbi Elyaqoubi², Gabriel Abba³
¹Arts Et Metiers Paristech, France; ²National Engineering College of Metz, France

This paper presents the energy consumption of a biped robot with a new modeled structure of knees which is called rolling knee (RK). The dynamic model, the actuators and the friction coefficients of the gear box are known. The optimal energy consumption can also be calculated. The first part of the paper is to validate the new kinematic knee on a biped robot by comparing the energy consumption during a walking step of the identical biped but with revolute joint knees. The cyclic gait is given by a succession of Single Support Phase (SSP) followed by an impact. The energetic criterion is minimized through optimization while using the simplex algorithm and Lagrange penalty functions to meet the constraints of stability and deflection of the mobile foot. An analysis of the friction coefficients is done by simulation to compare the human characteristics to the robot with RK. The simulation results show an energy consumption reduction through the biped with rolling knee configuration. The influence of friction coefficients shows the energy consumption of biped robot is close to that of the human.

Mathematical Model of Group Robots
Teturo Itami
Hiroshima International University, Japan

We have so far developed continuum mechanical simulation methods of group robots. Taking Hamiltonian with specified exponential function of time has allowed us to deal with motion of robots with friction also in canonical equation framework. We examine in this article results calculated by our continuum mechanical methods. We especially note the presence of collision among robots and dependence of calculation on number of robots. Also we try to make an object follow a required path.

Using Bearing-sensitive Infrared Sensor Arrays in Motion Localization for Human-following Robots
Yuebin Yang; Guodong Feng; Shaoxian Wang; Xuemei Guo; Guoli Wang
Sun Yat-sen University, China

This paper concerns the lightweight and robust infrared motion localization for human-following robots. We use bearing-sensitive pyroelectric infrared (PIR) sensor arrays in motion localization with two steps. The first step aims at generating bearing measurements of a human target from multiple perspectives with the PIR sensor arrays. The second step aims at locating the target through a least squares fusion of bearing measurements. The experimental results show that this approach ensures a human-following robot continuously working in an environment with complex background and light condition.

Indirect Adaptive Formation Control with Nonlinear Dynamics and Parametric Uncertainty
Samet Guler¹, Nasrettin Koksal¹, Baris Fidan¹, Veysel Gazi²
¹University of Waterloo, Canada; ²Istanbul Kemerburgaz University, Turkey

This paper focuses on coordination of multi-agent systems with agents having holonomic nonlinear dynamics and uncertain system parameters. An indirect adaptive control scheme is designed based on certainty equivalence, composed of a
parameter estimator and a feedback-linearization based control law. Model reference and sliding mode control structures satisfying stability condition are discussed independent of the path to be followed by the agents. Simulation results for a sample two-dimensional formation are presented, demonstrating the performance of the designed controllers.

26th June, Wednesday
14:00-15:20 at Malazgirt 2
WeC3 Nonlinear Control (IV)
Session Chair: Jacob Hammer, University of Florida, USA
Session Co-Chair: Lin Tie, Beihang University, China

Robust Passivity-Based Surge Control of Compressors via Feedback Linearization
Gholamreza Sari\textsuperscript{1}, Ouassima Akhrif\textsuperscript{2}, Lahcen Saydy\textsuperscript{3}
\textsuperscript{1}Polytechnique Montreal, Canada; \textsuperscript{2}École de Technologie Superieure, Canada
In this work, we address the stability of compression systems and the active control of surge. Despite considerable efforts to stabilize axial compressors at efficient operating points, preventing surge is still a challenging problem. Here, the two-state Moore-Greitzer model comprising close-coupled valve and including parameter uncertainties and external disturbances, is considered. A feedback linearization approach transforms the original nonlinear model into an equivalent linear system. A passivity-based control is then suggested to robustly stabilize the linearized system in the presence of external disturbances and model uncertainties. Time-domain simulations strongly corroborate analytical developments and demonstrate the robust performance of the controller.

Modeling of Parrot Ardrone and passivity-based reset control
Pablo Falcon, Antonio Barreiro, Miguel D. Cacho
Universidade de Vigo, Spain
This paper is motivated by the teleoperation of a quadcopter (Parrot ARDrone). This problem is addressed within the framework of passivity and by the reset control. First, the quadcopter model is identified from input-output experimental data. Second, the plant model is passified by nonlinear gain compensation and pole/zero cancelation. Finally, the passified plant model is controlled by a reset controller. The very-strict passivity (VSP) of the reset controller has been proven and discussed. Final simulations show the validity of the approach.

A Simple Approach to Nonlinear State Feedback Design
Jacob Hammer
University of Florida, USA
Global state feedback controllers that asymptotically and robustly stabilize a nonlinear system are derived from the solution of inequalities obtained directly from the controlled system’s equation.

On Stabilization of Continuous-time and Discrete-time Symmetric Bilinear Systems by Constant Controls
Lin Tie
Beihang University (Beijing University of Aeronautics and Astronautics), China
In this paper, the stabilization problems of two-dimensional symmetric bilinear systems by constant controls are considered. Both the continuous-time case and the discrete-time case are studied and necessary and sufficient conditions are presented. It is shown that if the control is multiple then the continuous-time system is stabilizable if and only if its discrete-time counterpart is stabilizable.

26th June, Wednesday
14:00-15:20 at Kocatepe
WeC4 Fault Detection (II)
Session Chair: Z.W. Zhong, Nanyang Technological University, Singapore
Session Co-Chair: Iyad Hashlamon, Sabanci University, Turkey

Correlation Analysis of Cutting Force and Acoustic Emission Signals for Tool Condition Monitoring
Z.W. Zhong\textsuperscript{1}, J.H. Zhou\textsuperscript{1,2}, Ye Nyi Win\textsuperscript{1}
\textsuperscript{1}Nanyang Technological University, Singapore; \textsuperscript{2}Singapore Institute of Manufacturing Technology, Singapore
Identification and estimation of cutting tool wear and surface roughness of the machined surface are important in the milling process. This paper presents the correlation analysis of cutting force, acoustic emission signals, tool life, and surface roughness. We present the details of the dominant features discovery, which have a high correlation with tool wear and surface roughness. The best compound features found by the correlation analysis are verified by multiple regression models and are used to construct fault estimation models. A case study of tool wear and surface roughness estimation is presented. The good agreement between the estimation results of real tool wear and surface roughness data demonstrates the usability of acoustic emission signals in tool condition monitoring.
A Ground Reaction Force Sensor Fault Detection and Recovery Method based on Virtual Force Sensors for Walking Biped Robots

Iyad Hashlamon, Kemalettin Erbatur
Sabanci University, Turkey

This paper presents a novel method for ground force sensor faults detection and faulty signal reconstruction using Virtual force Sensor (VFS) for slow walking bipeds. The design structure of the VFS consists of two steps, the total ground reaction force (GRF) and its location estimation for each leg based on the center of mass (CoM) position, the leg kinematics, and the IMU readings is carried out in the first step. In the second step, the optimal estimation of the distributed reaction forces at the contact points in the feet sole of walking biped is carried out. For the optimal estimation, a constraint model is obtained for the distributed reaction forces at the contact points and the quadratic programming optimization method is used to solve for the GRF. The output of the VFS is used for fault detection and recovery. A faulty signal model is formed to detect the faults based on a threshold, and recover the signal using the VFS outputs. The sensor offset, drift, and freezed output faults are studied and tested. The proposed method detects and estimates the faults and recovers the faulty signal smoothly. The validity of the proposed estimation method was confirmed by simulations on 3D dynamics model of the humanoid robot SURALP while walking. The results are promising and prove themselves well in all of the studied fault cases.

Multiple Fault Diagnosis Using Mathematical Models

Lotfi Mhamdi1, Hedi Dhouibi2, Noureddine Liouane1, Simeu-Abazi2
1ENIM, Tunisie; 2G-SCOP, France

Multiple fault diagnosis is a challenging problem because the number of candidates grows exponentially in the number of faults. The multiple fault problems is important, since the single fault assumption can lead to incorrect or failed diagnoses when multiple faults occur. In this work, we present an approach for diagnosing multi faults based on model using techniques of detection and localization. We use an observer to generate residuals for a decision in a stage of monitoring and diagnostic system when disruptions or defects occur. Our contribution is the proposal of a diagnostic method when multiple faults type actuators or sensors affect the system.

Fault Tolerant Synchronization for a Class of Uncertain Chaotic Systems versus External Disturbances using Fuzzy Sliding Mode Control

Faeez Farivar
Islamic Azad University, Iran

In this paper, fault tolerant synchronization (FTS) for a class of uncertain chaotic systems is investigated. The FTS system is to increase the safety and reliability of synchronization when the slave system is subjected to actuator and sensor faults. In this paper, the faulty slave system is considered with model uncertainty and external disturbances. A sliding surface is adopted to ensure the stability of the synchronization dynamics and employed to design a fuzzy control system. Based on Lyapunov stability theory and fuzzy rules, the nonlinear controller and some generic sufficient conditions for global asymptotic synchronization are attained. The fuzzy rules are directly constructed subject to a defined Lyapunov function such that the synchronization error dynamics of two identical chaotic motions satisfy stability in the Lyapunov sense. The fuzzy sliding control system can compensate the actuator faults, model uncertainties, and disturbances occurred in the slave system. The proposed method is applied to two chaotic systems; Genesio and Duffing systems. Numerical simulation results demonstrate the validity and feasibility of the proposed FTS method.

Control of Omni-directional gaits for Six Legged Robot

Woo-Young Jeong1, Bong-Huan Jun2, Hak Kyeong Kim1, Sang Bong Kim1
1Pukyong National University, South Korea; 2KORDI/MOERI, South Korea

This paper introduces omni-directional walking gait control of a six legged robot. The mathematic modeling of one leg is presented by forward kinematic. Six legged robot consists of its body and six legs. A leg has three links and three rotational joints. Relations between each angle of leg joints and end effector of a leg can be expressed by inverse kinematic. But inverse kinematic problem is difficult and complex to represent these relations. Therefore, a controller using differential kinematic algorithm is proposed for control one leg of six legged robot. Differential kinematic algorithm is developed based on back-stepping control using Lyapunov stability. A controller is designed to track trajectory of omni-directional walking motion for one leg with smooth and uniform velocity. A hardware control system of the six legged robot is developed based on DSP TMS320F28335 micro-controller and AX-12A servo motor with half duplex communication. Simulation and experimental results are shown to prove the effectiveness and applicability of the proposed controller.
Double Resonant Controller for Fast Atomic Force Microscopy
Sajal Das, Hemanshu Pota, Ian Petersen
University of New South Wales at Australian Defence Force Academy, Canberra
This paper presents the design and implementation of a double resonant controller with an integral controller in the piezoelectric tube scanner (PTS) of an atomic force microscope (AFM) to damp the resonant mode of the scanner, increase the bandwidth of the overall closed-loop system, and improve the high speed imaging performance of the AFM. The X and Y axes of the PTS is treated as an independent single-input single-output system and the system is identified by using the measured open-loop data. In order to measure the performance of the proposed controller a comparison of the scanned images have been made by using the proposed controller and the built-in proportional-integral (PI) controller of the AFM. The comparison of the scanned images demonstrate the performance improvement achieved by the proposed controller.

Study on the Pressure Feedforward Control of Electro-Hydraulic Load System
Biao Zhang, Yanliang Dong
Harbin Institute of Technology, China
How to eliminate the extra torque is a key problem of electro-hydraulic load system. Aimed at the characteristic of electro-hydraulic load system extra torque, different from conventional compensation methods, a rudder pressure feedforward compensation method is proposed. The mechanics of extra torque is analyzed by building the integrated model of electro-hydraulic load system. Then the rudder pressure feedforward compensation controller is built. Finally the simulation and experiment are operated by different controllers. Simulation and experiment results show that the proposed method can eliminate extra torque efficiently.

Micro Position Control of a Designed 3-PRR Compliant Mechanism Using Experimental Models
Merve Acer1, Asif Sabanovic2
1Istanbul Technical University, Turkey; 2Sabanci University, Turkey
A new compliant stage based on 3-PRR kinematic structure is designed to be used as a planar micro positioner. The mechanism is actuated by using piezoelectric actuators and the position of the center of the stage is measured by using a dual laser position sensor. It’s seen that manufactured mechanism has unpredictable motion errors due to manufacturing and assembly faults. Thus, sliding mode control with disturbance observer is chosen to be implemented as position control in x-y axes of the center of the mechanism. Instead of piezoelectric actuator models, experimental models are extracted for each actuation direction in order to be used as nominal plants for the disturbance observer. The position control results are compared with the previous position control using linear piezoelectric actuator models and it’s seen that the implemented control methodology is better in terms of errors in x and y axes. Besides, the position errors are lowered down to ±0.06 microns, which is the accuracy of the dual laser position sensor.

Consensus Control of a Class of Nonlinear Systems
Zhengtao Ding
The University of Manchester, UK
This paper deals with consensus control of a class nonlinear systems with Lipschitz nonlinearities. Certain features of the Laplacian matrix are further explored to identify conditions for global consensus control. Under the identified conditions, consensus control and stability of the proposed control are analysed in time-domain through Lyapunov functions. The proposed control uses relative state information of the system. A simulation study is included to demonstrate the proposed control designs with some simulation results shown.

Image Processing Based Defuzzification Method for Type-2 Fuzzy Systems
Mehmet Karakose, Semiha Makinist
Firat University, Turkey
Type-2 fuzzy logic systems are the systems that use the three dimensional fuzzy membership functions in order to minimize the effects of the indefiniteness not modelled by type-1 fuzzy systems. However, in type-2 fuzzy systems, the complexity in terms of calculation is much higher compared to type-1 fuzzy systems. Particularly the defuzzification stage of Type-2 fuzzy systems is a complex calculation process. In this study, an image process based algorithm was suggested for the defuzzification process of type-2 fuzzy systems. The suggested algorithm is both faster and easier to realize compared to those used in the literature. The method is based on converting the area composed of the active rules into black-white image and finding the weighted mean of the black parts in the image. The effectiveness of the defuzzification method suggested was shown in the simulation results provided.
Sliding Mode Online Learning Algorithm for Type-2 Fuzzy CMAC Networks
Sevil Ahmed, Kostadin Shiev, Andon V. Topalov, Nikola Shakev, Okyay Kaynak
Technical University of Sofia, Plovdiv campus, Bulgaria; Bogazici University, Turkey

Cerebellar model articulation controller (CMAC) networks have been widely applied to problems involving modeling and control of complex dynamical systems because of their computational simplicity, fast learning and good generalization capability. The integration of fuzzy logic systems and CMAC networks into fuzzy CMAC structures can help to improve their function approximation accuracy in terms of the CMAC weighting coefficients. Type-2 fuzzy logic systems are an area of growing interest over the last years. The ability to model uncertainties and to perform under noisy conditions in a better way than type-1 fuzzy systems increases their applicability. A new stable incremental learning algorithm for interval type-2 fuzzy CMAC (T2FCMAC) networks is proposed in this paper. The algorithm is based on the variable structure systems theory principles. It can tune online the parameters of the membership functions and the weights in the fourth and fifth layer of the T2FCMAC network. Simulation results from the identification of two nonlinear systems demonstrate the better performance of the T2FCMAC structure with the newly proposed algorithm in comparison to the on-line learning type-1 and type-2 Takagi–Sugeno–Kang (TSK) fuzzy neural networks.

Type-2 Fuzzy Based Quadrotor Control Approach
Ismail Ilhan, Mehmet Karakose
Mus Alparslan University, Turkey; Firat University, Turkey

Unmanned air vehicles has recently become applications that are being increasingly used in both unmilitary and military areas and that are popular fields of research. The quadrotor type among the unmanned air vehicles, which come in different types, sizes and models depending on their area of use, come into prominence with several advantages it offers. This study performs the modeling, simulation, altitude and direction controls by means of a type-2 fuzzy system of an unmanned air vehicle. A proper algorithm is required for a quadrotor due to the environmental conditions, uncertainty and noise effects. Therefore, type-2 fuzzy controller was preferred and the performance of type-2 controller was provided against the type-1 and PID control methods in the simulations were carried out in this study. Simulation results obtained in the study show the effectiveness of type-2 fuzzy controller over the other controllers.

Sliding Mode Type-2 Fuzzy Control of Robotic Arm Using Ellipsoidal Membership Functions
Mojtaba Ahmadieh Khanesar, Erdal Kayacan, Okyay Kaynak, Wouter Saeys
Semnan University, Iran; University of Leuven, Belgium; Bogazici University, Turkey

Several papers claim that the performance of the type-2 fuzzy logic systems is superior over their type-1 counterparts, especially under noisy conditions. In order to show the effectiveness of the noise reduction capabilities of the type-2 fuzzy logic systems, a novel type-2 fuzzy membership function, ellipsoidal membership function, has recently been proposed. The novel membership function has certain values on both ends of the support and the kernel, and some uncertain values on the other values of the support. The parameters responsible for the width of uncertainty are decoupled from the parameters responsible for the center and the support of the membership function. In this study, a sliding mode control theory based learning algorithm has been proposed to tune the consequent part parameters tuning of the ellipsoidal type-2 fuzzy membership functions. The applicability of the novel membership function with the proposed novel parameter update rules has been shown on the control of a 2DOF robotic arm. The simulation results show that the type-2 fuzzy neural networks working in parallel with conventional PD controllers have the ability of controlling the robotic arm with a high accuracy especially under noisy conditions.

Efficient Input Variable Selection for Calibration Model Design
Koichi Fujiwara, Manabu Kano
Kyoto University, Japan

In pharmaceutical processes, near-infrared spectroscopy (NIRS) is a key tool of process analytical technology (PAT), and very accurate calibration models need to be developed with NIR spectra. Partial least squares (PLS) regression, in particular, is accepted as a useful technique for calibration model design. When a calibration model is built, appropriate input variables have to be selected to achieve high estimation performance. Recently, a new methodology for selecting input variables based on nearest correlation spectral clustering (NCSC) has been proposed. Referred to as NCSC-based variable selection (NCSC-VS), it clusters input variables into some variable groups based on the correlation by using NCSC, and selects a few variable groups according to their contribution to output estimates. We report here an industrial application of NCSC-VS to calibration model design for a pharmaceutical process. NCSC-VS can select important variables and improve the estimation performance greatly in comparison to conventional variable selection methods.
Optimal Control of Crystallization of Alpha-Lactose Monohydrate  
Amira Rachah, Dominikus Noll  
University of Toulouse, France  
We discuss a model of solvated crystallization of alpha-lactose monohydrate. We then consider the problem of maximizing in semi-batch mode the crystal mass of particles produced in a small particle size range between $10^{-5}$ and $10^{-4}$ micro meter, by controlling temperature, feed rate, and by choosing an appropriate crystal seed.

A Novel ASM2 and SVM Compensation Method for the Effluent Quality Prediction Model of A²O Process  
Xiaoting Li¹, Feng Pan¹, Xiaofeng Lian², Miao Yu¹  
¹Beijing Institute of Technology, China; ²Beijing technology and business university, China  
For the soft measurement of water quality for sewage treatment process, a novel prediction model is proposed to predict the effluent water quality in this paper, which combines the mechanism model with compensation model. Firstly, the ASM2 model is built as the mechanism model to imitate the sewage treatment process, as well as PSO algorithm is used to adjust the kinetic parameters of the ASM2 model. Next, SVM regression is adopted to compensate the prediction error of mechanism model. Finally, the model is tested with real data collected in a sewage treatment plant. The simulation results show that the model can obtain accuracy prediction results and reflect the behavior of sewage treatment efficiently.

Modeling and Control for the Tube Blank Heating Quality of Seamless Tube  
Dong Xiao¹; Shaohua Shi¹; Jichun Wang¹; Zhizhong Mao¹  
¹Northeastern University, China; ²Liaoning University of Technology, China  
As the tube blank of seamless tube heating furnace system has some characteristics, such as multivariable, nonlinear, large lag, cross coupling, etc., to predict and control the outlet temperature of tube blank is always a difficult problem in the industrial circle, which is the main factor that affects the quality of seamless tube. Based on the PCA method, this paper puts forward TLPCR method, and use it to establish the model that can predict final temperature of the tube blank. In the end, testing the model bases on the actual production data from baosteel. According to the check and error analysis indicate that the predicted error by model can satisfy the precision requirement of industrial application.

Multi-Scale Predictive Modeling for Achromic Power in a Lithopone Calcination Process Based on EMD  
Jing Yao¹; Qiliang Du²  
¹Guangzhou University, China; ²South China University of Technology, China  
In order to predict achromic power, one of the most important quality indices of the semi-product in a Lithopone rotary kiln, a predictive model based on time series modeling technique was focused on. According to the Lithopone calcination mechanism, the multi-scale feature of the process was introduced. Empirical Mode Decomposition, an adaptive data-driven method, was applied to settle the coupling of different time scales. Autoregressive model was used to model every Intrinsic Mode Function decomposed, and GM(1,1) model was used to model the trend series. By combining these models, a multi-scale predictive model for achromic power was obtained eventually. The simulation results show its promising performance. This approach serves as a motivation for similar processes such as cement kilns and ceramic kilns.
A Simulation Study of GPS/INS Integration for Use in ACC/CACC and HAD
Ilker Altay¹, Bilin Aksun Guvenc², Levent Guvenc³
¹Istanbul Technical University, Turkey; ²Istanbul Okan University, Turkey
Use of communicated GPS position and velocity information in adaptive cruise control and cooperative adaptive cruise control with the purpose of cooperative driving and the use of GPS position for automated path following in highly automated driving are two current research applications requiring fast and accurate GPS updates. Based on previous experience, a GPS/INS integration system is presented in this paper to allow faster updates as compared to the use of GPS only and to provide accurate position/velocity information in the presence of temporary losses of GPS fix. An INS algorithm and GPS/INS integration are presented in this paper in a realistic simulation setting. The aim is to analyze the effects of different sampling rates of sensors, errors, covariances and to use GPS/INS fusion to broadcast position data at a higher rate than GPS. The DCM method is used to estimate rotations in an inertial measurement unit. Drifts and biases are seen to be the main error sources. As a prerequisite before road testing with our experimental vehicle, GPS/INS is fused using the extended Kalman filter in a highly realistic simulation setting.

Stabilizing Control of An Autonomous Bicycle
Harun Yetkin, Umit Ozguner
The Ohio State University, USA
The problem of self-stabilization of a bicycle has been a research area for more than a century. However, many researchers have confined their study in self stabilization of bicycles at constant velocities. In this paper, we utilized the precession effect of the gyroscope to stabilize the bicycle both at zero forward velocity and varying velocities. Equation of motion of a bicycle with a flywheel mounted on its bottom is derived and a first order observer-based sliding mode controller is designed. The performance of the controller is simulated on different road structures. It is shown that the designed controller succeeded to stabilize the bicycle throughout the trajectory.

Multi-Variable Double Resonant Controller for Fast Image Scanning of Atomic Force Microscope
Sajal. K. Das, Hemanshu R. Pota, Ian R. Petersen
The University of New South Wales at ADFA, Australia
This paper presents the design and implementation of a multi-variable double resonant controller with a multi-variable integral controller on the piezoelectric tube scanner (PTS) of an atomic force microscope (AFM) to damp the resonant mode of the scanner, reduce the cross coupling between the axes of the scanner, increase the bandwidth of the overall closed-loop system, and improve the high speed imaging performance of the AFM. The lateral and longitudinal positioning system of the PTS is treated as a multi-input multi-output system and the system is identified by using the measured open-loop data. The controller parameters are obtained by minimizing the H2 norm of the difference between the desired and the actual closed-loop transfer function and the performance improvement achieved by the proposed controller is shown by comparing the scanned images obtained by implementing the proposed controller and the built-in proportional-integral (PI) controller of the AFM.

A Novel Robust MPC Based Aircraft Auto-Throttle for Performing 4D Contract Flights
Vangelis Petratos¹, Dimitrios Dimgianopoulos², Fotis Kopsaftopoulos³, Spiillos Fassios¹
¹University of Patras, Greece; ²Technological Education Institute of Piraeus, Greece
A novel robust auto-throttle controller for use within a Four-Dimensional Contract (3D+Time) flight context is introduced. The controller design utilizes typical receding horizon techniques, with control values resulting from optimizing the predicted system response over future time intervals. The novelty is two-fold: First, the controller is conceptually designed to optimize the aircraft fuel efficiency (represented by the Specific Fuel Consumption-SFC) along with its position during the 4D flight. Second, the control value admits a closed-form expression, thus greatly simplifying its on-board calculation. Tests against conventional PID-based auto-throttle controllers illustrate the current controller’s superior robustness under challenging flight conditions (turbulence).

Fuzzy Control for Balancing of a Two-Wheel Transportation Robotic Vehicle: Experimental Studies
Hyunwook Kim¹, Seul Jung²
¹LIG Nex1, South Korea; ²Chungnam National University, South Korea
This paper presents an experimental study of fuzzy control application to balance two-wheel transportation vehicle for a commuter. A two-wheel transportation vehicle is controlled to convey a driver in urban environment. The vehicle has two driving modes, mobile robot mode with 4 contact points and balancing robot mode with two contact points on the ground. Nominal fuzzy rules are applied to control the balance of two-wheel vehicle. Experimental studies of balancing the two-wheel vehicle are demonstrated.
Compensation for Long Arm Payload by a Non Model-Based Disturbance Observer
Yeonggeol Bae, Seul Jung
Chungnam National University, South Korea

This paper presents a compensation technique for unknown payloads of extra-long arms of a mobile manipulator aimed for home services. In the Cartesian movements of robot arms, linear acceleration can be measured by an accelerometer and be used to estimate the disturbance configured in the disturbance observer (DOB) scheme. Here, it is assumed that robot model parameters are totally unknown. Experimental studies are conducted to confirm that the acceleration-based DOB improves the tracking performance of the robot arm in the Cartesian space.

Investigating the Security Control of A Water System: An Overview
Yu-Lun Huang, Ya-Hsuan Wang
National Chiao Tung University, Taiwan

This paper introduces the role of a PCS in a critical infrastructure, and especially addresses the processing flow and control of a water system. By leveraging advanced IT technologies, a modern process control system (PCS) can help monitor and control physical processes in a water system. Conventionally, a water system is composed of a water treatment subsystem and a water distribution subsystem. To provide better water quality and steady water flow, PCSs should be adopted in these subsystems to more precisely control the concentration of chemicals in water and the outlet valve of water tanks. We investigate the security issues and possible attacks in a water system adopting a close-loop control mechanism. Taking the concentration control of chlorine in water as an example, we formally explain how an integrity attack leads a water system into a harmful state by adding improper amount of chlorine into water. In the future, we will further develop a formal model describing a n-tank water system, evaluate the impact of simultaneous more attacks and discuss the potential impacts. We will also try to design a detection and defence system to resist against known attacks.

LPV Controller Design with Multiple Parameters for the Nonlinear RTAC System
Nam Kyu Kwon, Bum Yong Park, Poogyeon Park
Pohang University of Science and Technology, South Korea

This paper proposes linear parameter varying (LPV) model with multiple parameters (LPV-MP) and state-feedback controller for the nonlinear rotational and translational actuator (RTAC) benchmark problem. First, based on LPV-MP, the conditions used for designing the state-feedback controller are formulated in terms of parameterized linear matrix inequalities (PLMIs) and the state-feedback LPV controller using multiple parameters-dependent Lyapunov function (MPDLF) is designed. Then, PLMI conditions are converted into linear matrix inequalities (LMIs) by using a parameter relaxation technique. The proposed method results in the reduced decision variables and simulation results show good performance of the proposed method.

A Mechanism for Surgical Tool Manipulation
Basem Fayez Yousef, Farah M.T. Aiash
United Arab Emirates University, UAE

A compact mechanism is designed to enable manipulation about a pivot point, different kinds of surgical tools which are commonly used in minimally invasive surgery such as therapy laser delivery tools, biopsy and brachytherapy needles. The robot’s special configuration will enable it to re-orient a surgical tool about a pivot point conveniently; achieve and control small-scale movement for precision manipulation in two independent degrees of freedom, and allow for miniaturization so it can overcome problems associated with the limited surgical workspaces. The manipulator can be used in manual, autonomous or remote-control modes. Performance analysis showed that the robot can operate with an average angular accuracy of 1.4 and 1.1 degrees for the joints. The features of the proposed mechanism make it well suited for use in a broad range of medical interventions.
Design of Intelligent Optimal Energy Management System for Hybrid Power Sources
Rong-Jong Wai, Shih-Jie Jhung
Yuan Ze University, Taiwan

This study designed an intelligent optimal energy management system for hybrid power sources including a fuel cell (FC) system and a battery module. In the proposed intelligent optimal energy management system, a simple fan temperature control is introduced to reduce the possible energy waste during the startup of the FC system. Moreover, a fuzzy hydrogen control is designed to manipulate the FC system stably and generate the same unit power with less hydrogen. In addition, a stable adaptive current-voltage fast-charging control is investigated to improve the charge speed in conventional constant current/constant voltage (CC/CV) scheme with proportional-integral (PI) control. The objectives of fast charging, energy saving, power source protection, and system stability assurance can be simultaneously achieved. Furthermore, the effectiveness of the proposed intelligent optimal energy management system is verified by experimental results. Its merits are indicated by comparing a conventional management system without the fan temperature control and with a fixed hydrogen pressure and a CC/CV charging framework.

Application of Intelligent Systems and DSP to Landing Controller Design
Cheng-Yen Yu, Jih-Gau Juang
National Taiwan Ocean University, Taiwan

This paper presents different artificial life algorithms and the cerebellar model articulation controller (CMAC) to aircraft automatic landing control design. The artificial life algorithms are bacterial foraging optimization (BFO), particle swarm optimization (PSO), chaos particle swarm optimization (CPSO) and bacterial swarm optimization (BSO). Wind shear is introduced in flight simulations. Conventional aircraft automatic landing system can not be used in such environment during serious wind speed changes. The proposed intelligent control scheme can help the pilots guide the aircraft to a safe landing in difficult environment. The proposed controller is realized by a TI DSP.

Nonlinear Model Predictive Control of An Uninhabited Surface Vehicle
Robert Sutton, Sanjay K Sharma
Plymouth University, UK

This paper presents a novel nonlinear autopilot design based on a nonlinear model predictive control (NMPC) approach that is compared against a linear quadratic Gaussian control scheme. The autopilot systems are used to control the nonlinear yaw dynamics of an uninhabited surface vehicle named Springer. The yaw dynamics of the vehicle being modelled using a multi-layer perceptron neural network. Simulation results are presented and the performances of the autopilots are evaluated and compared using standard system performance criteria and indices. The autopilot based on the NMPC method is deemed the more apt of the two types examined for Springer in terms of control activity expenditure, power consumption and mission duration length.

Analysis on Marketing Capabilities of IT Listed Company in China: An Empirical Study Based on Stochastic Frontier Method
Gelin Chen\textsuperscript{1,2}, Hongsheng Xia\textsuperscript{1}
\textsuperscript{1}Jinan University, China; \textsuperscript{2}Guangdong College of Industry and Commerce, China

This paper studies on marketing capabilities of IT listed company in China based on stochastic frontier method. Corporate marketing capability is defined as a transformative process that converts inputs into marketing-related outputs. Through empirical analysis, it founds that the marketing capabilities of IT Listed Company in China is very low. And there is a close correlation between marketing capabilities and firm size and firm age. The marketing ability of large and elder corporate is relatively high.
Mechanical Property Control System for Cold Rolled Steel Sheet through Locally Weighted Regression Model

Hiroyasu Shigemori
JFE Steel Corporation, Japan

A new control method is proposed for controlling mechanical property in cold-rolled steel sheet production process. The proposed method is based on a locally weighted regression model, which is a type of Just-In-Time models. The mechanical property control system using the proposed method was developed and has been applied to actual plants. The proposed method determines the optimal heat treatment temperature from the information of the pre-processes which has actual process data. Significant effects on reducing mechanical property deviations and model maintenance load have been achieved in commercial production. The developed system has made contributions to improving yield and production rate.

Control Strategies for Removing Nitrogen Compounds in Wastewater Treatment Plants

Henry Rafael Concepcion¹, Darko Vrecenko², Montse Meneses¹, Ramon Vilanova²
1University at Autonoma de Barcelona, Spain; 2Jožef Stefan Institute, Slovenia

This paper presents the application of different control strategies applied for wastewater treatment plants (WWTP). The main purpose is to evaluate its effectiveness/cost trade-off attending a set of criteria. The study has been performed by using the Benchmark Simulation Model No. 2 (BSM2) and the evaluation criteria have been selected taking into account the most relevant indicators provided by this benchmark scenario. More specifically, five strategies have been implemented and compared with the default closed loop control strategy (DCL) of BSM2 and between them. Results show that the control strategies that use the ammonia cascade controller provide better results in most of the evaluated criteria than the control strategies implemented by using only the oxygen controller. Ammonia controller improves the results in terms of effluent quality and operational costs due to the reported aeration energy savings. As a conclusion of this study the control strategy that uses the ammonia and carbon controllers has been selected as the most recommended for implementation.
design, Neuro-Fuzzy Inference System (ANFIS) is proposed. ANFIS, which combines neural network and fuzzy logic, are adopted and applied to the linear mathematical model to perform position, force and viscosity controls. By training the correct data, membership functions for the fuzzy logic can be obtained through ANFIS toolbox in MATLAB. Closed-loop control for IPA system is conducted and performance the Proportional-Integral (PI) ANFIS controller is analyzed and compared with conventional PI controller. Simulation results show that PI ANFIS controller performed better than conventional PI controller in terms of position, force tracking and viscosity control.

**PH Control in Biological Process Using MMPC based on Neuro-Fuzzy Model by LOLIMOT Algorithm**

Ali Saada, Ahmad Akbari Alvanagh, Hamed Rezaei  
*Sahand University of Technology, Iran*

pH control is considered as one of the most important issues in chemical and biological processes. Although process has simple components but control of pH in output effluent is difficult in application. The main reasons of this difficulty are highly nonlinearity and time varying nature of the process. Multi-model predictive controller using neuro-fuzzy model based on LOLIMOT algorithm is employed to control pH value in this study. The distinctive features of these controllers that can be expressed are the ability to generalize to multi-variable systems, design in time domain, the ability to handle system with delay, nonlinear and non-minimum phase processes. For this purpose nonlinear process is divided into local linear model using LLNF (Local Linear Neuro-fuzzy) model, each linear model is in CARIMA format and generalized model predictive controller is designed for each linear model and final control input is weighted of controller output of each linear model. Finally by the implementation of designed controller on experimental setup, improvement of responses can be observed.

**A New Sparse Reconstruction Algorithm for Device-free Localization with Sensor Network**

Zhiyong Yang, Kaide Huang, Guoli Wang  
*Sun Yat-Sen University, China*

Device-free localization (DFL) is an emerging technology for localizing targets by monitoring the changes in the radio frequency (RF) attenuation field of an area where a wireless sensor network is deployed. Notably, this technology does not require the targets to participate in the localization effort by carrying any electronic device. Considering that the targets typically distribute in the interesting area sparsely, this paper presents an algorithm named advanced expectation conditional maximization either (ECME) thresholding pursuits (AEMTP) to realize DFL based on the compressed sensing (CS) theory. The proposed AEMTP algorithm utilizes the received signal strength (RSS) measurements of wireless links in the sensor network to reconstruct a shadow fading image and locates the targets on the none-zero pixels. The AEMTP algorithm introduces a greedy strategy that each iteration detects a support set F on the base of the ECME iteration. Then the sparse image is reconstructed by solving a truncated least-squares problem on the support set F. The experimental results reveal that the localization accuracy of the AEMTP algorithm could reach to around 0.51m by using 20 nodes in a 5m×5m square area.

**A Bias-Compensated Affine Projection Algorithm for Noisy Input Data**

Sang Mok Jung, Nam Kyu Kwon, Poogyeon Park  
*Pohang University of Science and Technology, South Korea*

This paper proposes a bias-compensated affine projection algorithm (BC-APA) to eliminate bias due to noisy input data and to reduce the performance degradation due to highly correlated input data. A new affine projection algorithm (new APA) using innovative input data is presented for highly correlated input data. We analyze the bias in this innovative new APA under noisy input data and remove it. To remove the bias, an estimation method for the input noise variance is presented and explained. In simulations, the BC-APA provided both fast convergence rate and small mean square deviation. Based on improved precision to estimate a finite impulse response of an unknown system, the BC-APA can be applied extensively in adaptive signal processing areas.

**Defect Detection and Width Estimation in Natural Gas Pipelines Using MFL Signals**

Mojtaba Rostami Kandroodi1, Farshad Shirani1, Babak Nadjar Araabibi1, Majid Nili Ahmadiani1, Maisam Mansob Bassiri2  
1*University of Tehran, Iran; 2*Segal Pardazesh engineering Co., Iran

Magnetic Flux Leakage (MFL) testing is the most widely used non-destructive techniques for the in-service inspection of oil and gas pipelines. In this study, a novel approach for detecting and estimating the width of defects by employing MFL signals is presented. Estimating the locations of defects and profiles of lengths, widths, and depths of defects from measurements is a typical inverse problem in electromagnetic non-destructive testing. In this study, defect parameters are
estimated in two separate consecutive steps. In the first step, a detection algorithm based on image processing approaches is applied on axial flux to estimate the numbers of defects, locations, and orientations of defects. Then, to estimate widths of defects, an inversion procedure based on 2D signal processing is applied on radial flux corresponding to areas detected in previous step. Finally, the efficacy and accuracy of the proposed algorithm is validated through examinations on simulated defects and real experimental MFL data. Simulated defects are generated in presence of multiple uncertainties and noises.

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**26th June, Wednesday**

16:20 - 17:20 at Barbaros B

**WeD7**  
System Biology

**Session Chair:** Miki Shimada, Waseda University, Japan  
**Session Co-Chair:** Tatsuo Kitajima, Malaysia-Japan International Institute of Technology, Malaysia

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**Contribution of Voltage-dependent Ion Channels to Subthreshold Resonance**

Tatsuo Kitajima¹, Zhonggang Feng²  
¹University Teknology Malaysia, Malaysia; ²Yamagata University, Japan

Subthreshold resonance has been observed in many excitatory/inhibitory neurons in the brain and it is suggested that such resonance phenomena play an important role in behavioral or perceptual functions in animals. Various voltage-dependent channels are thought to be involved in the generation of these resonance oscillations. For a compartmental neuron model with Ca²⁺-dependent K⁺ channel and low-threshold Ca²⁺ channel, conductance-based channel dynamics are linearized around equilibrium states and a neuron model can be treated as an equivalent RLC electric circuit, which indicates that the subthreshold resonance may be attributable to inductive properties of voltage-dependent channels. By computer simulation, we examine how parameters of these voltage-dependent channels, such as an equilibrium potential and the amplitude, effect to generate a subthreshold resonance.

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**A Gain Scheduling Model of Temperature Compensation for Circadian Rhythm of Cyanobacteria**

Miki Shimada, Kenko Uchida  
Waseda University, Japan

KaiC phosphorylation cycle generates the circadian rhythm without transcription and translation of kai genes. We use the model proposed by Kurosawa et al, which describes KaiC phosphorylation process in DD case, to study the mechanism of circadian rhythm. Temperature compensation is one of the most important features of circadian rhythm, therefore some methods to construct temperature compensated model have been proposed. We apply the gain scheduling method proposed by Takeuchi to the model. We focus on the other essential feature 'temperature entrainment'. Using temperature compensated model under temperature cycle, we look at phase shift of the model and how this model is entrained by temperature.

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**Closed-Loop Nonlinear Adaptive Control of Anti-angiogenic Tumor Therapy**

Ugur Hasirci¹, Timothy C. Burg², Richard E Groff²  
¹Duzce University, Turkey; ²Clemson University, USA

A nonlinear adaptive backstepping controller for the anti-angiogenic tumor growth control problem is presented. The proposed control algorithm directly aims to drive the tumor volume along a desired trajectory as part of a treatment regimen. Toward this aim, we first present an exact-model knowledge controller that ensures the exponential tracking of a time-varying tumor volume profile, and then, an adaptive controller is shown that provides asymptotic tracking despite model uncertainties. A Lyapunov-based analysis approach is used to determine stability and performance results. Numerical simulation results are presented to demonstrate the performance of the proposed approach. Finally, the requirements of a real-time implementation of an in-vitro model of the overall system are discussed.
POSTER SESSIONS
An Efficient Method for Finite Time Stability Calculation of Continuous Time Delay Systems

I. Buzurovic¹, D. Lj. Debeljkovic², A.M. Jovanovic³
¹Harvard University, USA; ²University of Belgrade, Serbia

This paper provides sufficient conditions for the finite time stability of linear continuous time delay systems mathematically described as \( x(t) = A_0 x(t) + A_1 x(t-\tau) \). A novel method was used to derive new delay dependent conditions. The conditions obtained were applied in the system stability analysis. Consequently, the aggregation function does not have to be positive in the state space domain, and does not need to have the negative derivatives along the system trajectories. Finite time stability was analyzed using the novel conditions derived in the paper. The described approach was compared with some known methods. It was proved that the new results were in compliance with the previously reported results, but more convenient for numerical calculations. The numerical example was presented to support the results.

Stabilization for Polytopic Uncertain Switched Linear Systems with Constant Input

Takuya Soga, Naohisa Otsuka, Genki Nakayama, Akihiro Tojo
Tokyo Denki University, Japan

In this paper, we study stabilizability problems for polytopic uncertain continuous-time switched linear systems with constant input via various types of switched rules. Firstly, sufficient conditions for an equilibrium point of polytopic uncertain switched linear systems with constant input to be stabilizable via different two types of state feedback switched rules are presented. Next, sufficient conditions for an equilibrium point of the same systems to be stabilizable via different two types of switched rules which depends on the state of switched observer are presented. Further, two illustrative numerical examples are also investigated.

Improved Delphi Method with Weighted Factor and its Application

Wen Ji, Jianhui Wang, Xiaoke Fang, Shusheng Gu
Northeastern University, China

In view of long duration, high costs and expert evaluation value with many extreme points of the Delphi method, using the fuzzy method, this paper proposes an improved Delphi method with weighted factor in order to reduce the influence of subjective factors and shorten the consulting time. Then, it applies the improved Delphi method to simulate in the context of stroke rehabilitation evaluation system. Simulation results show the effectiveness of the proposed method.

A Note on Representation of Nonlinear Time-Varying Delay-Differential Equations as Time-Delay Feedback Systems

Tatsuya Yamazaki, Tomomichi Hagiwara
Kyoto University, Japan

This paper is concerned with the relationship between delay-differential equations (DDEs) and time-delay feedback systems, and studies the conversion problem of nonlinear time-varying (NLTV) DDEs into representations as time-delay feedback systems, i.e., NLTV systems in feedback connection with pure delays. We first introduce adequate definitions of the solutions of the initial value problems for DDEs under possibly discontinuous initial functions, together with appropriate assumptions for ensuring the global existence and uniqueness of such solutions. We then tackle the conversion problem and solve it including the conversion of initial conditions, and discuss the relation of the conversion method with an existing result confined to linear time-invariant DDEs.

An Weighted Error Controller for A Class of Distributed Parameter Systems

Nirvana Popescu¹, Decibal Popescu², Mircea Ivanescu³
¹University Politehnica, Romania; ²University of Craiova, Romania

The paper treats the control problem of a class of distributed parameter systems described by hyperbolic partial differential equations. The controllers are obtained using the concept of boundary geometric control and a weighted error control technique. A control algorithm is proposed and the stability is analyzed. Then, for a dynamic model with uncertain components, a robust algorithm based on weighted error Sliding Mode Control is discussed. Numerical simulations are also provided to verify the effectiveness of the presented approach.

A Stability Criterion for Fractional-Order Systems with-order in frequency domain: The 0<\alpha<2 case

Zhe Gao, Xiaozhong Liao, Bo Shan, Hong Huang
Beijing Institute of Technology, China

This paper proposes a stability criterion for linear fractional-order systems with the commensurate order \( 0<\alpha<2 \) satisfying \( 1<\alpha<2 \). The angle increment of the characteristic function in a linear fractional-order system is investigated, and the stability condition with respect to the angle increment is presented in the frequency domain. By this condition, we present a stability criterion to verify the stability of a linear fractional-order system according to the
A New Algorithm for Decomposition Problem of Binary Fuzzy Relations
Hongbiao Fan, Jun-e Feng, Lequn Zhang, Hongli Lv
Shandong University, China;
This paper deals with the decomposition problem of a binary fuzzy relation defined in the Cartesian product of finite spaces. First, a necessary and sufficient condition on the solvability of the problem is shown. Then logical equations are converted into algebraic equations via semi-tensor product (STP) approach. With it, all solutions of the problem can be obtained by the proposed method. Finally, an illustrative example is shown to demonstrate effectiveness of the derived algorithm.

Multiresolution Wavelet PID Control for Global Regulation of Robots
F.A. Diaz-Lopez\textsuperscript{1}, L.E. Ramos Velasco\textsuperscript{2}, O.A. Dominguez Ramirez\textsuperscript{3}, V. Parra-Vega\textsuperscript{4}
\textsuperscript{1}Higher Technological Institute of Huichapan Hidalgo, Mexico; \textsuperscript{2}Polytechnic University of Pachuca, Mexico;
\textsuperscript{3}Hidalgo State University, Mexico; \textsuperscript{4}Research Center for Advanced Studies (Cinvestav), Mexico
A novel global PID control scheme for nonlinear MIMO systems is proposed and implemented for a robot. Inverse dynamics identification is synthesized using a radial basis neural network with daughter RASP1 wavelets activation functions in cascaded, with an infinite impulse response (IIR) filter in the output to prune irrelevant signals and nodes. This information is used for online tuning of feedback gains of a discrete PID controller. The resulting scheme is a self-tuning time-varying feedback gain linear PID regulator that guarantees global regulation for nonlinear dynamical plants, such as robots. Real-time experimental study is carried out on a three degrees of freedom haptic interface, the PHANTOM Premium 1.0A. Results highlight the performance in global regulation with smooth control effort, without using the mathematical model of the robot.

Backstepping Control of Polymerization Reactor
Pinpanki Biswas\textsuperscript{1}, Amar Nath Samanta\textsuperscript{2}
\textsuperscript{1}Raw Materials & Coke making Group, R&D, Tata Steel Ltd., India; \textsuperscript{2}Indian Institute of Technology Kharagpur, India
This paper presents adaptive backstepping methodology for controlling polymerization process under parametric uncertainty and input saturation. In general controlling complex chemical processes is a challenging problem due to the structural mismatch and uncertainty of parameters. Adaptive algorithm, whether linear or non-linear, is an essential tool to control such processes. Normally, nonlinear adaptive controllers are designed based on stability of Lyapunov functions. A recursive backstepping design approach is applied here for constructing Lyapunov functions and designing nonlinear control laws for controlling temperature and monomer concentration of polymerization process. The adaptive algorithm is also able to tackle other parametric uncertainties along with input saturation. The controller structure has a strong disturbance rejection capability and also robust to model uncertainties for polymerization process. A number of parameters are adapted for obtaining better result and the controller gives a stable performance in presence of significant parametric uncertainty. The proposed adaptive controller is capable of handling both matched and unmatched uncertainties.

Computation of Parametric Convergence Bound and Parametric Convergence Margin for Volterra series Expansion
Zhenlong Xiao, Xingjian Jing, Li Cheng
Hong Kong Polytechnic University, Hong Kong
In this paper, the concepts of Parametric Bound of Convergence (PBoC) and Parametric Convergence Margin (PCM) are proposed. The estimation of PBoC and PCM are presented explicitly in terms of the characteristic parameters, which do not require any recursive computation. An example is given to illustrate and validate the presented results.

Backstepping Position Control of Two-Mass Systems with Unknown Backlash
Mirhamed Mola, Alireza Khayatian, Maryam Dehghani
Shiraz University, Iran
This paper presents a backstepping control strategy to control the load position of two-mass systems with unknown backlash. The measurable signals for applying this nonlinear control law are assumed to be available from motor and load sides. For achieving the desired control goals, a pre-control block is designed too. This block which is fed by motor and load measurable signals, drives the required signals for the nonlinear backstepping control law. The simulation results on a sample two-mass system illustrate the effectiveness of the proposed algorithm.

Observer-Based Fuzzy Control Design for Discrete-Time T-S Fuzzy Bilinear Stochastic Systems with infinite-distributed delays
Jiangrong Li\textsuperscript{1}, Junmin Li\textsuperscript{2}, Yu Li\textsuperscript{1}
\textsuperscript{1}Yanan University, China; \textsuperscript{2}Xidian University, China
This paper is concerned with the problem of observer-based fuzzy control design for discrete-time T-S fuzzy bilinear stochastic systems with infinite-distributed delays. Based on the piecewise quadratic Lyapunov functional (PQLF), the fuzzy observer-based controllers are designed for T-S fuzzy bilinear stochastic systems. It is shown that the stability in the mean
square for discrete T-S fuzzy bilinear stochastic systems can be established if there exists a set of PQLF can be constructed and the fuzzy observer-based controller can be obtained by solving a set of nonlinear minimization problem involving linear matrix inequalities (LMIs) constraints. An iterative algorithm making use of sequential linear programming matrix method (SLPMM) to derive a single-step LMI condition for fuzzy observer-based control design. Finally, an illustrative example is provided to demonstrate the effectiveness of the results proposed in this paper.

Wide Area Equipment Protection System Based on Substation Panoramic Information
Jungang Li, Chen Li, Yuanxin Zhang, Aimin Zhang, Hang Zhang, Yingsan Geng
Xi'an Jiaotong University, China
This paper proposes a Wide area Equipment protection (WAEP) system which based on substation panoramic information realize wide area relay protection function. Firstly, substation station level and bay level abolished, deploy comprehensive intelligent equipment in substation process level, realizes substation local protection and panoramic information collection which provide sufficient information for WAEP; secondly, based on Packet Transport Network (PTN) realize pseudo wire communication to ensure the reliability and real-time of information transfer. thirdly, coordinated relay mechanism of substation local protection and WAEP, realize equipment protection system. The experiment proved that this method achieved wide area protection.

Finite Time Stability Control Based on Higher-Order Sliding Mode for TORA System
Jie Yang, Qinglin Wang, Yuan Li
Beijing Institute of Technology, China
Translational oscillators with rotating actuator (TORA) system is a challenge for controller design because of its underactuated character. A finite time stability control method based on higher-order sliding mode is proposed to achieve finite time stability under uncertainty for the TORA system. The TORA dynamical model function is transformed to cascade normal forms. For the second order subsystem, virtual control is introduced and the finite time stability proof is given with the conception of terminal sliding mode. Actual variable tracking virtual control in finite time is achieved by higher-order sliding mode controller. Adaptive robust method is proposed to solve uncertainty problem with unknown upper bounds, and proof of finite time stability is given. Simulation results verify the robustness of the methods.

Analysis and Modeling of A Control System Based on Digital Dynamic Pulse Frequency Modulation for Objects with Transport Delay
Bekmurza H. Aitchanov1, Olimzhon A. Baimuratov1, Vladimir V. Nikulin2
1K.I.Satpaev Kazakh National Technical University, Kazakhstan; 2State University of New York, USA
This paper is focused on digital dynamic pulse-frequency modulation (DPFM) control systems that can be implemented on a microcontroller. We describe a structure of a discrete nonlinear closed-loop system that is equivalent to DPFM. A general-case model of a digital modulator of I-th order is obtained and an example of implementation and performance of an electric drive control system is presented.

Flatness Control Strategy for the Air Subsystem of A Hydrogen Fuel Cell System
Ramon Da Fonseca1, Eric Bideaux1, Mathias Gerard1, Bruno Jeanneret1, Ali Sari2, Matthieu Desbois-Renaudin3, Didier Buzon4
1Ampere Laboratory, France; 2CEA, France; 3IFSTTAR, France
In this paper, a non linear control strategy is applied to the air supply subsystem of a polymer electrode membrane fuel cell (PEMFC). Based on a simplified control model and using the differential flatness control theory, a controller is designed in order to regulate the most important variables in the air supply subsystem: the oxygen stoechiometry and the cathode pressure. The non linear control approach is validated using a real fuel cell system, presenting a good response compared with a PID classical approach.

New Input-Output Pairing Based on Eigenvalue Contribution Measures
Adel Ahmadi, Mohammad Aldeen
University of Melbourne, Australia
In this paper, a new approach based on the concept of combined controllability and observability is proposed to quantify the interaction among the inputs and outputs of both stable and unstable linear multivariable systems. The proposed approach computes the contribution of the system eigenvalues in the outputs and formulates a Relative Contribution Array (RCA) to quantify the input-output interactions and select the most appropriate set of input-output pairs. The proposed approach has many advantages over existing well known approaches, which are illustrated through a widely reported numerical example of a chemical process where conventional RGA is shown to lead to improper pairings while the proposed approach leads to far more accurate assessment of interaction.

An LMI Framework to Design Robust MPC for a class of Nonlinear Uncertain Systems
V. Ghaffari1, S. Vahid Naghavi2, A. Akbar Safavi1, Masoud Shafiee3
1Shiraz University, Iran; 2Amir kabir University of technology, Iran
This paper presents a linear matrix inequality (LMI) Framework to design robust MPC for a class of continuous-time nonlinear uncertain systems. The controller design is formulated as an optimization problem of the “worst-case”
objective function over an infinite moving horizon. A sufficient state feedback synthesis condition is provided in the form of LMI optimization and is solved online at each time step. A simulation example is showed the effectiveness of the proposed method.

Model Predictive Controller Performance Monitoring Based on Impulse Response Identification
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Model predictive control has been applied widely recently. But many model predictive controllers cannot be operated for a long time, the main reason is that there is lacking of model predictive controller performance monitoring system, then the model predictive controller is absent from self-healing ability. Based on Haar scale transform, a method of identification of impulse response for closed-loop sensitivity function and complementary sensitivity function is proposed. Combining the principle of model predictive control and robustness analysis, a method of model predictive controller performance monitoring based on identified impulse response for closed-loop sensitivity function and complementary sensitivity function is proposed. Simulation results and industrial application results have verified the feasibility and effectiveness of the proposed method.

Study of Multiple Model Predictive Control On a pH Neutralization Plant
Ali Shamsaddini1, Alireza Fatehi1, Ali Khaki Sedigh1, Mohammad Mahdi Karimi2
1 K.N. Toosi University of Technology, Iran; 2 Training University, Iran

Nonlinear behavior and disturbance sensitivity of the pH processes causes them to be known as an appropriate test bench for advanced controllers. Because of special behavior and varying parameters of pH processes, Multiple Model Predictive Controllers (MMPC) have better performance than other controllers from both regulation and disturbance rejection points of views. Two new supervisory methods based on prediction error and fuzzy weighting for MMPC are presented. Better regulation in special condition and most excellent disturbance rejection in comparison to other MMPC methods are achieved.

Predictive Control of Large Steam Turbines
Mojtaba Kordestani1, Majid S. Khoshro2, Alireza Mirzaee1
1 Shiraz University, Iran; 2 Iran Power Plant Project Management Company, Iran

This study presents the application of predictive control techniques consisting of General Predictive Control (GPC) and Constrained Receding-Horizon Predictive Control (CRHPC) to regulate the output power of large steam turbines. The performance of the control system has been verified by the simulation process and then tested on real-time process under the set point tracking and load disturbance. Results show the better performance of CRHPC in comparison with GPC in term of much accuracy and less fluctuations in the plant responses.

A Dynamical Search Space Harmony Search for Unconstrained Optimization Problems
Jing Wang1, Wei Jiang2, Liulin Cao1, Qibing Jin1, Wang Wei2
1 Beijing University of Chemical Technology, China; 2 Hebei Energy College of Vocation and Technology, China

A dynamical search space harmony search (DSHS) algorithm in order to improve the efficiency of standard harmony search algorithm. The DSHS employs two strategies which are dynamically changing the search space and ancillary harmony-memory to increase the diversity of harmonies and the global search ability. First the ratio of twin-harmony is defined which is an index of identifying the diversity of harmonies in the Harmony Memory (HM). Then the search space is dynamically changed according to the max ratio of twin-harmony. Finally, ancillary harmony-memories are introduced to replace worse harmonies in the HM, which can keep the main HM from getting into troubles of HM diversity lacking and the local minimum point. Various benchmarks and PID tuning problem are performed to demonstrate the effectiveness of proposed algorithm.

Control of Omni-Directional Mobile Vehicle for Obstacle Avoidance Using Potential Function Method
Giang Hoang, Hak Kyeong Kim, Sang Bong Kim
Pukyong National University, South Korea

This paper proposes a tracking controller for obstacle avoidance of an omni-directional mobile vehicle (OMV) using potential function method through a ceiling-mounted camera system. To do this task, the followings were done. At first, for image processing, a ceiling-mounted camera system was installed to get images. The goal point and obstacles were separated and recognized by a color recognition method. Second, potential function method was proposed to generate the shortest path to avoid obstacles from the start point to the goal point. The mobile platform is a mecanum wheel omni-directional vehicle. Third, the tracking controller is designed for the OMV to track a trajectory generated by a path planning algorithm based on the backstepping method using Lyapunov function. Finally, the simulation results were presented to show the effectiveness of the proposed trajectory planning algorithm and tracking controller for obstacle avoidance of the OMV.
Sliding-Mode Observer Design for Sensorless Vector Control of AC Induction Motor
Phuc Thinh Doan, Thanh Luan Bui, Hak Kyeong Kim, Sang Bong Kim
Pukyong National University, South Korea
In this paper, a sliding-mode observer is applied to control an AC induction motor. First, the modeling of AC induction motor is presented. After that, a sliding mode observer is proposed to estimate the motor speed, the rotor flux, the angular position of the rotor flux and the motor torque from monitored stator voltages and currents. The proposed sliding mode observer provides very good performance for both low and high speed motor operation. Furthermore, the proposed system is robust in motor losses and load variations. The convergence of the proposed observer is obtained using the Lyapunov theory. Hardware and software for simulation and experiment of the AC induction motor drive are introduced. The hardware consists of a 1.5kw AC induction motor connected in series with a torque sensor and a powder brake. A controller is developed based on DSP TMS320F28355. The simulation and experimental results illustrate that fast torque and speed response with small torque ripples can be achieved. The proposed control scheme is suitable to the application fields that require high performance of torque response such as electric vehicles.

Trajectory Tracking Controller Design for AGV Using Laser Sensor Based Positioning System
Phuc Thinh Doan, Thanh Luan Bui, Hak Kyeong Kim, Sang Bong Kim
Pukyong National University, South Korea
This paper introduces a tracking controller for Automatic Guided Vehicles (AGV) to track a desired trajectory. The use of the nonlinear Lyapunov technique provides robustness for load disturbance and sensor noise. Based on kinematic model, a trajectory tracking controller of AGV is proposed. System stability are verified by Lyapunov stability. A laser sensor device NAV200 is used to detect the AGV position in door environment in real-time. For simulation and experiment, software and hardware are described. The AGV consists of 4 wheels with two passive wheels and two driving wheels. A controller is developed based on industrial computer. The effectiveness of the proposed controller is proved by simulation and experimental results.

Control of Resonant Modes of a Smart Structure Using OMPC
M. S. Rana, H. R. Pota, I. R. Petersen, H. Habibullah
The University of New South Wales, Australia
In this paper the design and experimental implementation of an observer based model predictive control (OMPC) scheme for active damping of the first two resonant modes of a smart structure is presented. The design of this controller is based on an identified model of the plant. A Kalman filter is used to obtain full state information. The experimental results verify the efficacy of the proposed controller.

Stability Analysis of Dynamic Quantized Systems with Time-varying Delay
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This paper studies the stability of a discrete-time dynamic quantized system with time-varying delay in the state feedback loop. A newly proposed dynamic quantizer, which is able to minimize the quantized error, is improved by bringing several dynamic elements into its static part. By the so-called lifting method, the dynamic quantized discrete-time system with time-varying delay is transformed into a switched system. Asymptotic stability of the system is considered using common Lyapunov function approach, and a sufficient condition for stability is developed in terms of matrix inequalities. A numerical simulation is finally given to show the effectiveness of the proposed method.

Instability of Uncertain Large-Scale Networks
Masaki Inoue1, Jun-ichi Imura2, Kenji Kashima3, Kazuyuki Aihara4
1Japan Science and Technology Agency, Japan; 2Tokyo Institute of Technology, Japan; 3Osaka University, Japan; 4The University of Tokyo, Japan
This paper is concerned with instability analysis of uncertain large-scale networks. First, we present an instability counterpart of the small gain-type robust stability condition for uncertain linear systems with no network structure. Then, we extend the instability condition to that for a class of uncertain large-scale networks. Every node in the network has certain homogeneous dynamics and uncertain heterogeneous dynamics. Finally, an illustrative example is presented for instability analysis of an uncertain cyclic gene network model.

Finite-Time Consensus Tracking of Multiple Coupled Harmonic Oscillations via Bounded Control
Haibo Du1, Yigang He2, Yingying Cheng1
1Southeast University, China; 2Hefei University of Technology, China
This paper considers the problem of finite-time consensus tracking for multiple harmonic oscillators with a leader-follower architecture. By using the techniques of finite-time control and saturation control, a class of bounded finite-time controllers are first proposed. Then to address the case in the presence of external disturbance, a finite-time convergent disturbance observer is constructed to estimate the disturbance in a finite time. Finally, a disturbance observer-based bounded finite-time controller is developed. Rigorous proof shows that the systems states can reach consensus in a finite time and the final consensus states are the leader’s states.
A Novel Apparatus for Motion Control Experiments
Manh-Tuan Ha, Chul-Goo Kang
Kekuk University, South korea
In control class, students usually have some confusion when they imagine about operation of a system. Motion control education in engineering requires hands-on experiments to catch the concept of control systems, but experimental apparatus for motion control experiments is expensive, complex in mechanism and is also hard to use in general. Therefore, a motion control apparatus which is easy to use, simple and reliable is very useful for students. This paper shows a novel apparatus which used for motion control experiments. This apparatus can be experimented conventional PID control logics and especially it can be done with real-time control purpose, and advanced control logics with cheap prices. The validity of the developed motion control apparatus is demonstrated by testing PD control logic and ZVD input shapers experimentally.

Vibration Suppression of Size-Dependent Modified Couple stress Timoshenko Micro-Beams
Ramin Vatankhah1, Ali Najafi2, Hassan Salarieh1, Aria Alasty1
1Sharif University of Technology, Iran; 2Islamic Azad University, Iran
The problem of boundary control of a vibrating size-dependent micro-cantilever Timoshenko beam is considered in this research to achieve the asymptotic stability of the closed loop system. For this purpose, it is necessary to establish the well-posedness of the governing Partial Differential Equations (PDEs) of motion in the presence of boundary feedbacks. A linear boundary control law is constructed and applied at the tip of the micro-beam to stabilize the system vibration. In this paper, operator theory, semigroup techniques, Lyapunov stability and LaSalle’s invariant set theorems are used to demonstrate the well-posedness and asymptotic decay rate of the controlled system.

Time Delay Sensitivity Analysis in A Wireless Network Control System Using LMI Approach
Mohammad Mahdi Delbari, M. Taghi Hamidi Beheshti, Amin Ramezani, Sadjaad Ozgoli
Tarbiat Modares University, Iran
A Wireless Network Control System (WNCS) with time delay and possibility of packet dropouts is considered. As we know packet dropouts and time delays are much more of concerns in wireless data networks compared to wired networks. Because of this importance the sensitivity of the designed controller for the discussed WNCS is studied when various time delay profiles are present in the networked control system. The results are then compared and a conclusion is stated.

Data Loss and Delay Distribution of Wireless Sensor Networks
Tian Zheng1, Abdelkader El Kame1, Shaoping Wang2
1Ecole Centrale de Lille, France; 2Beihang University, China
The communication system of intelligence vehicle platform is consist of a series of wireless communicators which is formed like wireless sensor network (WSN). Each of the vehicles behaves like a sensor in the WSN. The status data of the environment and the vehicle have been gathered and transmitted to a certain sink, another vehicle or the control center. So the quality-of-service (QoS) of the network should be guaranteed to ensure the reliability of the whole platform. QoS of the WSN has been wildly analyzed. This paper is focused on the data loss and the delay as the main characters of the QoS of WSN. The result can provide a reference for the estimation of the reliability of the control system based on the WSN such as intelligence vehicle platform.

Satellite Map based Quantitative Analysis for 3D World Modeling of Urban Environment
Hyun Chul Roh, Taek Jun Oh, Yungeun Choe, Myung Jin Chung
KAIST, South Korea
Here we present 3D world modeling and its quantitative analysis methods in urban environment. If the expensive RTK GPS cannot be prepared, it is difficult to measure the accuracy of the 3D world model due to the blackout of GPS particularly in urban environment. To cope with this difficulty, we combine to process both satellite image and point cloud to compare each other in order to represents accuracy of 3D world model. We also introduce 3D world modeling method through localization algorithm and global registration method in order to validate our quantitative analysis. In the experimental result, we describe our sensor system and evaluate the proposed quantitative analysis method using 3 different localization algorithm. Our framework is suitable of mobile mapping system in urban environment in terms of cost.

A Linearization Reference Node Selection Strategy for Accurate Multilateration Localization in Wireless Sensor Networks
Quanrui Wei, Jiuqiang Han, Jun Liu
Xi’an Jiaotong University, China
Localization algorithm is a important issue in Wireless Sensor Networks. Multilateration is one of the most well-known distributed localization methods. In this paper, we analyze the effect that the reference node selection on positioning results, and propose a linearization reference anchor node selection strategy to improve the localization accuracy. The proposed sLS method and sWLs method don’t require additional hardware, and can be easily implemented. Finally, simulation results are conducted to demonstrate the efficiency of the sLS method.
An New Strategy for Online Evaluation of Analog Circuit Performance Based Adaptive Least Squares Support Vector Regression with Double Kernel RBF Tuning

Xing Huo¹, Aihua Zhang², Pengda Qin³
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In this paper, a novel strategy for online evaluation of analog circuit performance based on adaptive least squares support vector regression machine is proposed. Regarding reducing the computation, simultaneously, employing double kernel RBF to interface more flexibility to the kernel function online such as the bandwidths. And the design idea and constructed steps based on adaptive least square support vector regression with double kernel RBF tuning are introduced. Experiment adopted the typical circuit Sallen-Key low pass filter to prove the proposed evaluation strategy via the performance eight indexes. Simulation results show that the evaluation performance and the testing speed, especially the testing speed of the proposed is superior to that of the traditional LSSVR and ε-SVR, which is suit for applying online

Study on the Operating Mode of SNS in EC Environment of China

Xiufeng Li
Shandong Normal University, China

SNS, whose full name is the Social Networking Site, means the social networking services, specifically internet applications designed to help people build social networks. In this paper we start with the status and the competition of social networking sites in China; then to make use of SWOT model to find out the condition of the market, pointing out the development trend of the social networking site: “No service, no business.” E-commerce, video, search, SNS are four plates of the Internet, the plates can not exist independently. With the user groups and information created by social networking, the combination between the plates will not only provide abundant real content, but also can achieve mutual complementarities of resources and achieve lasting positive development.

Automotive Infotainment Power Management Solution by Modeling, Analysis and Control of 42V/14V DC-DC Automotive Interleaved Buck Converter

Anila Thyagarajan, Raja Prabu, G. Uma
B.S. Abdur Rahman University, India

This paper will focus on the Power Management solution of vehicles via Modeling, analysis and simulation of a 42V/14V dc/dc converter based architecture. This architecture is considered to be technically a viable solution for automotive dual-voltage power system for passenger car in the near future. An interleaved dc/dc converter system is chosen for the automotive converter topology due to its advantages regarding filter reduction, dynamic response, reduced ripples and power management. Presented herein, is a model based on one kilowatt interleaved six-phase buck converter designed to operate in a Discontinuous Conduction Mode (DCM). The control strategy of the converter is based on a voltage-mode-controlled Pulse Width Modulation (PWM) with a Proportional-Integral-Derivative (PID). The effectiveness of the interleaved step-down converter is verified through simulation results using Matlab/Simulink.

Gradient Based Iterative Identification for Discrete-Time Delay Systems

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In this paper, we apply a hierarchical identification principle to identify simultaneously the unknown time delay and dynamic parameters of discrete-time delay systems. In our approach, we separate the nonlinear cost function into two simple cost functions and present a gradient iterative algorithm for estimating directly the time delay and the parameters. Furthermore, we give an appropriate choice of the convergence factor. Finally, the effectiveness of this method has been illustrated through simulation.

Depth and Normal Vector Identification of An Unknown Slope From A UAV Using A Single Camera

Zhichao Liu, Jianliang Wang, Eng Kee Poh, Suresh Sundaram
Nanyang Technological University, Singapore

Abstract—This paper presents a novel vision-based system to estimate the normal vector of an unknown slope and the range from a camera fixed on a UAV to the slope using a single camera. An exact point-based image moments model considering the camera’s focal length is presented. Using the model, a fast estimator is designed to estimate the image flow with high precision. The continuous model is then discretized using Taylor series method. Finally, a particle filter is used to obtain a solution to the estimation problem. The whole system estimates simultaneously the normal vector of the unknown slope and the depth from the camera on the UAV to the slope.

Robust Unscented Kalman Filter via l_1 Regression and Design Method of Its Parameters

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In this paper, we propose a robust unscented Kalman filter (RUKF) using l_1 regression and a new design method of its regularization parameters. Generally, the regularization parameters in l_1 regression are designed by heuristic methods, so the parameters have no physical senses. However, in our design method, it is shown that statistics of Gaussian noise...
determine the parameters of the RUKF, and we can design the parameters systematically. The proposed RUKF is applied to a state estimation of a two-link manipulator with outliers, and the effectiveness is demonstrated by numerical simulations.

**Takagi-Sugeno Fuzzy Observer and Extended-Kalman Filter for Adaptive Payload Estimation**

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In this paper, two nonlinear state estimation methods, Takagi-Sugeno fuzzy observer and extended-Kalman filter are compared in terms of their ability to reliably estimate the velocity and an unknown, variable payload of a nonlinear servo system. Using the system dynamics and a position measurement, the velocity and unknown payload are estimated. In a simulation study, the servo system is excited with a randomly generated step input. In real-time experiments, the estimation is performed under feedback-linearizing control. The performance of the TS fuzzy payload estimator is discussed with respect to the choice of the desired convergence rate. The application results show that the Takagi-Sugeno fuzzy observer provides better performance than the extended-Kalman filter with robust and less parameter dependent structure.

**Unscented Kalman Filter for An Orientation Module of A Quadrotor Mathematical Model**

Jarolaw Gosinski, Wojciech Giernacki, Stanislaw Gardecki  
Poznan University of Technology, Poland

The article describes the Unscented Kalman Filter, used in an orientation module of the quadrotor. Control of the quadrocopter is an important issue. Since it belongs to the group of the UAVs (Unmanned Aerial Vehicle), quadrotor must pass safety requirements in order to be used in urban spaces. Here, authors are solving one of the most important problems: estimation of the state vector of the quadrotor. Multirrotors like quadrotor can work in semi autonomous or full autonomous mode. Regardless of the used mode, at least one control loop must be always on: an orientation loop. Normally a regulator responsible for an orientation stabilization is based on measurements from IMU (Inertial Measurement Unit). Here, an extended version of the state estimator, based on IMU readings and prediction from the model is introduced. Authors have implemented the Unscented Kalman Filter and proved that, this estimator is suitable in case of UAV.

**Parameter Identification of Bacterial Growth Bioprocesses using Particle Swarm Optimization**

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This paper deals with the off-line parameters identification for a class of bacterial growth bioprocesses using particle swarm optimization (PSO) techniques. Particle swarm optimization is a relatively new heuristic method that has produced promising results for solving complex optimization problems. In this paper one uses some variants of the PSO algorithm for parameter estimation of a complex biotechnological system. The identification problem is formulated as a multi-modal numerical optimization problem with high dimension. The performances of the method are analyzed by numerical simulations.

**Estimation of Time Delayed System with Complex Order Based Integrator**

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In this study a method to approximate first order time delayed systems in piece-wised frequency domain is proposed. This method uses the idea of fractional complex-based order integral operator. In this paper, first an augmented integrator relation based on the complex order with four degree of freedom is introduced. These parameters are treated as independent parameters to make the approximation accurate. Meanwhile a gain at a critical frequency is added to keep the steady state behavior. The validity and performance of the proposed novel approximation technique is shown when it is applied on a first order delayed-time system. Simulation results verify the quality of the technique with respect to the Pade approximation.

**Optimization via Characteristic Functions of Cones**

Jimmie Lawson  
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As Finsler metrics generalize Riemannian metrics, so one can generalize Lorentzian metrics to the consideration of manifolds equipped with a cone field and an appropriately smooth function F on the tangent bundle such that F restricted to each tangent space yields a so-called "length function" for the cone assigned to that point. This provides a type of quantification of a typical situation arising in nonsmooth analysis and control. As in Lorentzian geometry, one considers "forward" curves in the manifold which are length maximizing. In this paper we consider how the methods of optimal control can be applied to the study of these curves.
An Augmented Neural Network Algorithm for Solving Singular Convex Optimization with Nonnegative Variables
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Singular nonlinear convex optimization problems have been received much attention in recent years. Most existing approaches are in the nature of iteration, which is time-consuming and ineffective. Different approaches to deal with such problems are promising. In this paper, a novel neural network model for solving singular nonlinear convex optimization problems is proposed. By using LaSalle’s invariance principle, it is shown that the proposed network is convergent which guarantees the effectiveness of the proposed model for solving singular nonlinear optimization problems. Numerical simulation further verified the effectiveness of the proposed neural network model.
Optimized Real-Time Soft Analyzer for Chemical Process Using Artificial Intelligence
Mohammad Mahdi Karimi1, Alireza Fatehi2, Reza Ebrahimpour1, Ali Shamsaddiniou2
1 Training University, Iran; 2 K. N. Toosi University of Technology, Iran
This paper concerns application of data-derived approaches for analyzing and monitoring chemical process instruments, extracting product information, and designing estimation models for primary process variables, or difficult to measure in real-time variables. Modeling of process with an optimized classical neural network, the multi-layer perceptron (MLP) is discussed. Tennessee Eastman Process, a well-known plant wide process benchmark, is applied to validate the proposed approach. Investigations and several algorithms as step response test, Lipschitz number method and forward selection are used. The main advancement introduced here is that a hierarchical level responsible strategy is applied for selection of input variables and respective efficient time delays to attain the highest possible prediction accuracy of the neural network model for industrial process identification.

Combined RGBD-Inertial based State Estimation for MAV in GPS-denied Indoor Environments
Dachuan Li1, Qing Li1, Nong Cheng1, Qinfan Wu1, Jingyan Song1, Liangwen Tang2
1 Tsinghua University, China; 2 Flight Automatic Control Research Institute, China
This paper presents a integrated navigation approach for state estimation of a micro aerial vehicle (MAV) that is capable of autonomous flight in GPS-denied, indoor environments. The solution combines RGB-D sensor and inertial sensors in a tight-coupling navigation manner. Motion estimates from RGB-D visual odometry and inertial measurements are fused using an improved Extended Kalman Filter-based fusion algorithm to provide an accurate estimate of the relative position, velocity and attitude. Instead of using a global reference frame, a view-based map is employed and the algorithm maintains the position and heading relative to the current map node in the fusion algorithm. In addition, a closed-form covariance is developed to qualify the uncertainty of the RGBD visual odometry measurements, which is utilized for state update of the navigation filter. Our approach allows efficient measurement updates and enables the incorporation of RGBD visual odometry uncertainty. Experimental results of a quadrotor MAV flying in a GPS-denied indoor environment demonstrate the performance of the proposed approach. Comparisons of state estimates with ground truth measurements are also provided.

An Effective Computational Method for Human Splice Sites Identification
Jiujiang Han, Ying Cui, Jun Liu, Xinman Zhang
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Owing to the vast amount of DNA sequence data, the prediction of the complete structure of genes from the genomic DNA sequence becomes an important issue. For the eukaryotes, especially for the human genome, the splice sites identification plays a crucial role in gene structure prediction. A hybrid feature extraction approach which combing the position weight matrix (PWM) with the increment of diversity (ID) was proposed. Based on the extracted features, the support vector machine (SVM) was applied to classify authentic and false splice sites. The new algorithm was shown to be effective and simple. By the proposed algorithm, 92.98% of donor sites and 90.46% of acceptor sites were correctly classified. It is anticipated that the novel computational method is promising for the identification of splice sites in human genome.

An Effective SNR Gene Prediction Algorithm Based on Merge of Nucleotide Segments (MNS)
Jiujiang Han, Yucheng Ma, Jun Liu, Rong Bao, Ji-guang Zheng
Xi’an Jiaotong University, China
Signal processing approaches, among the deterministic approaches in gene prediction, have been attracting significant attentions in genomic DNA research for its fine model-independent feature and less reliance on known datasets. An effective SNR gene prediction algorithm based on merge of nucleotide segments (MNS) was proposed in this paper. A fast calculation equation for SNR was also derived. The new algorithm is effective, efficient and could be applied to various higher life forms, especially mammals. The AUC of MNS on Homo sapiens & mus musculus is 0.8073, and the AUC of MNS on various mammals is 0.7780, which are satisfying results among deterministic approaches. It is anticipated that the novel algorithm is promising for the prediction of various higher life forms, of which the DNA data information are limited. Testing results of MNS on various species implied the relationship between a species’ period-3 property and its evolutionary scale, which indicates that MNS could also be utilized as an auxiliary approach for taxonomy.

A Control Design Method for Unknown Systems Using Frequency Domain Data
Sofiane Khadraoui1, Hazem Nounou1, Mohamed Nounou1, Aniruddha Datta2, Shankar P. Bhattacharyya3
1 Texas A&M University at Qatar, Qatar; 2 Texas A&M University, USA
This paper deals with fixed-structure controller design for stable linear systems by using measurements. Most control design approaches developed in the literature are generally based on a mathematical model which can be obtained via identification system by using a set of measured data. However, an identified model, which is often built on the basis of
some assumptions, cannot perfectly describe complex behaviors characterizing physical systems. Thus, the performance expected for the closed-loop system will be limited by the quality of such models used in the control design process. Hence, data-based controller design methods can be viewed as a possible alternative to model-based methods. In this paper, we propose to directly utilize frequency response data in the controller design. The principle is to design fixed-structure controllers for which the closed-loop frequency response fits a desired frequency response. This problem is formulated as an error minimization problem. The main feature of our proposed approach is that controller can be designed free of any mathematical model, which allows to avoid errors associated with identification process. Moreover, it enables to select low-order controllers, which are suitable for embedded systems. A simulation example is given to illustrate and validate the efficacy the proposed approach.

Full and Partial Parametrizations of Stabilizing Controllers with Two-Stage Compensator Designs
Kazuyoshi Mori
The University of Aizu, Japan
In this paper, we investigate parametrization of stabilizing controllers of feedback system configured by `full’ two-stage compensator design. We show that, based on any stabilizing controller, the two-stage compensator design can give every stabilizing controller. We also show parametrizations of alternative `partial’ two-stage compensator designs.

On Design of Multi-rate Sampled-Data Output Feedback by Maximizing RSR
Xiaoy Li1, Huiliang Jin1, Qingchang Zhong2
1Shanghai Jiao Tong University, China; 2University of Liverpool, UK
This paper investigates Multirate sampled-data control system optimization design by considering robust stability of linear time-invariant uncertain systems described by affine parameter-dependent model. Extend Lyapunov upper bound robust stability test to develop a new condition for robust stability test of such system and give out a reliable numerical algorithm. For a given compensator F, define the maximum uncertainty set radius that the system is stable with as RSR (robust stability radius). Then convert the RSR calculation problem into a mathematical process of solving an equation by analyzing the robust stability test condition proposed. Solve the equation with Numerical Mathematical methods and get the analytical solution as RSR. At last we can define the RSR as a function of F and achieve F optimization design by a general optimization method to get the biggest RSR. With this F, the system can remain stable with the uncertain parameters vary set being the largest.

Flexible Beam Robust H∞ Loop Shaping Controller Design Using Particle Swarm Optimization
Roja Eini
Noushirvani University of Technology, Iran
In this paper fixed-structure H∞ loop shaping control strategy in conjunction with an evolutionary algorithm is proposed to design a robust controller for the flexible beam system so that its total vibration energy is minimized. Robust controller designed by the conventional H∞ loop shaping method is not an appropriate controller for a beam because of its high order and complicated form. H∞ loop shaping control under a fixed-structure controller is used to overcome this difficulty; however, tuning of structured controller parameters is difficult. Cost function is established considering the performance and robust stability conditions of the H∞ loop shaping controller, and particle swarm optimization (PSO) is then applied to optimize parameters and cost function. The proposed control design and loop shaping method are successfully applied on the flexible beam, and results of the two approaches are compared finally. Simulation results show the superiorities of the proposed controller in terms of having a lower order and simple structure; besides the beam stability and robust performance are retained as well.

Communication Disturbance Observer Approach to Control of Integral Plant with Time Delay
Mumin Tolga Emirler1,2, Bilin Aksun Guvenc2, Levent Guvenc2
1Istanbul Technical University, Turkey; 2Okan University, Turkey
The presence of time delay can cause stability problems in closed loop systems as it adds large negative phase angle to the system frequency response. The Smith predictor is a well-known method of dealing with fixed and known time delays in control systems. Errors in the knowledge of the time delay will cause degradation of the Smith predictor compensation performance. A solution to this problem is to use a communication disturbance observer. Time delayed integral plants are typical examples of open loop unstable systems with time delay. In this paper, the communication disturbance observer based time delay compensation method is applied to high order time delayed integral plants. A robust stability condition is derived for time delayed feedback control systems with the communication disturbance observer. The effect of the communication disturbance observer Q filter cut-off frequency selection on robust stability is investigated. Simulation results are presented for both constant and time varying delays to illustrate the effectiveness of the proposed communication disturbance observer approach.

GA-based Sliding Mode Controller for Yaw Stability Improvement
Norhazimi Hamzah1, Yahaya Md Sam2, Hazlina Selamat2, M Khairi Aripin3
1Universiti Teknologi MARA, Malaysia; 2Universiti Teknologi Malaysia, Malaysia; 3UTeM, Malaysia
The vehicle handling and stability can be enhanced with direct yaw moment control (DYC). In this paper, a sliding mode controller (SMC) with genetic algorithm optimization is proposed for the yaw moment control. A single track vehicle model with nonlinear tire forces is utilized for the controller design. The effectiveness of the proposed controller is compared to
conventional sliding mode controller by co-simulations in CarSim and Matlab/Simulink. The simulation results of a step steer maneuvers shows that the proposed controller give better performance in tracking the desired yaw rate and control other necessary response for the vehicle handling and stability. In addition, the chattering phenomenon is also reduced, giving a smooth tracking trajectory.

System Identification and Robust Controller Design for the Autopilot of An Unmanned Helicopter
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One of the most complex issues which are proposed in designing a controller for autopilots is robustness. This requirement is due to the dynamic model changes and also, the resistance to environmental disturbances. A main factor that changes the dynamic model of the helicopter autopilot is any change in body mass center, such as any additional load. Furthermore, wind is one of the main causes of environmental disturbances. In this paper model identification of four systems in helicopter by using real data is presented. For all systems robust H2/H∞ and mixed sensitivity controller are designed. The simulation results show the robustness of designed controllers in the existence of uncertainty. The designed controller was implemented on the real case study. Results demonstrate the robustness of the system.

A New Image Denosing Method Based on Wavelet Transforms
Shuqing Jiao
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A new method for image denoising was presented, which colligated the strong point of wave atoms transform and Cycle Spinning. Due to lack of translation invariance of wave atoms transform, image denoising by coefficient thresholding would lead to Pseudo-Gibbs phenomena. Cycle Spinning was employed to avoid the artifacts. Experimental results show that the method can remove noisy and remain edges, while Pseudo-Gibbs phenomena are controlled efficiently, and can get better visual effect and PSNR gains compared with the methods like simplex wave atoms or wavelet denoising using Cycle Spinning. And in heavy background noise, this advantage is significant.

Cooperative Area Reconnaissance for Multi-UAV in Dynamic Environment
Jie Chen, Wenzhong Zha, Zhihong Peng, Jian Zhang
Beijing Institute of Technology, China

The increasingly complex battlefield environment has put forward higher requirement on Unmanned Aerial Vehicle (UAV) system, where the cooperative area reconnaissance (CAR) is the primary task for multi-UAV. However, the current research results hardly balance the optimality and real-time property. Especially, how to avoid and process emergent threats is rarely considered for UAV formation. So this paper researched on the problems of CAR for multi-UAV in dynamic environment to obtain optimum efficiency on the premise of ensuring real-time. Firstly, the mathematical model and optimization framework were established. Then the idea of Model Predictive Control (MPC) was introduced to process this model and an improved Particle Swarm Optimization (PSO) algorithm based on Simulated Annealing (SA) was proposed to solve the optimization problem. Furthermore, the termination condition of searching was defined and processing strategies in multiple emergent conditions were represented specially. Finally, analysis and comparison of the results from established simulation platform verified that the methods proposed in this paper could control the UAVs avoiding the static and mobile threats effectively, accomplishing task perfectly with more than 90% reconnaissance coverage rate and the run-time of each prediction step was only 1.3892s.

Neural Network Based Terminal Iterative Learning Control for Tracking Run-Varying Reference Point
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1Nanyang Technological University, Singapore; 2Qingdao University of Science & Technology, China

In this paper, a neural network based terminal iterative learning control (NNTILC) method is proposed for a class of discrete time linear run-to-run systems to track run-varying reference point with initial state disturbance. An iterative training radial basis function (RBF) neural network is developed to estimate the effect of initial state on terminal output and to learn the changes in initial state iteratively at the same time. By involving these information in the control scheme, the proposed NNTILC can drive the system to track run-varying reference point fast and precisely beyond the initial disturbance and reference change. Stability and convergence of this NNTILC method is proved and computer simulation results confirm its effectiveness further.

Control Algorithm of a Smart Grid Device for Optimal Radial Feeder Load Reconfiguration
D.V. Nicolae, J.A. Jordaan
Tshwane University of Technology, South Africa

Secondary distribution network, generally speaking, performs as well as the performance of its LV feeders. The main problem a feeder is experiencing is the load unbalancing due to the stochastic nature of its individual single-phase loads: bigger losses in certain phase accompanied with bed voltage regulation and voltage unbalance. The aim of this paper is to address the issue of automatic balancing as progressing from the end of the feeder towards the front using smart device based on three-ways switch selector and artificial intelligence algorithm to minimize the neutral current.
Image Classification with Bag-of-Words Model Based on Improved SIFT Algorithm
Huilin Gao, Lihua Dou, Wenjie Chen, Jian Sun
Beijing Institute of Technology, China

The common method of image classification based on traditional SIFT local feature description makes the description of the global information not comprehensive and has complicated calculation because of the construction of scale extreme space. In addition, the feature space is high dimensional and sparse which will result in low classification accuracy, data redundancy and time-consuming process. The paper adopts a new image classification method with Bag-of-Words model based on improved SIFT algorithm. Each image is divided into a lot of uniform grid patches and the single scale SIFT feature descriptor with 128 dimensional is extracted in each patch. Then combine the PCA theory to reduce the dimensions of SIFT feature vector from 128 d to 20 d. Next, the BOW model of the image will be obtained by visual vocabulary. Finally establish the support vector machine (SVM) classifier based on radial basis function (RBF) and histogram intersection kernel (HIK) function respectively with the data above for training and testing. The optimal scheme is concluded through comparison of experimental results. The experimental results show that, the method presented in this paper shows higher classification accuracy.

RBF Neural Network Controller Based on OLSSVR
Kemal Ucak, Gulay Oke
Istanbul Technical University, Turkey

In this paper, a predictive adaptation method based on Online Least Square Support Vector Regression (OLSVR) for a RBF controller has been proposed. System Jacobian is approximated via Online LSSVR model of the system to tune RBF controller. The parameters of the controller have been tuned depending on K-step ahead future behavior of the system to provide adaptation ability to the controller under changing conditions. Levenberg Marquard algorithm is utilized as learning algorithm for controller parameters. The proposed method has been evaluated by simulations carried out on a magnetic levitation system, and the results show that the control performance has been improved.

Omni-Directional Spherical Mobile System Control
Chih-Hui Chiū1, Ya-Fu Peng2
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In this study, an omni-directional spherical mobile system (ODSMS) based on a dual Mamdani-type fuzzy control strategy (DMTFC) is implemented. The key feature of this robot is it can move directly in any direction with no constraint. Since the dynamic characteristic of the ODSMS is highly nonlinear, a fuzzy control strategy without system information is designed. The stability of DMTFC system, which is based on the Lyapunov stability theorem, can be ensured without any strict constraint. The effectiveness of the proposed control system is verified by ODSMS real-world implementation.

Iterative Learning Control Method for Permanent Magnet Synchronous Liner Motor based on Vector Control
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Beijing Information Science & Technology of University, China

Based on the analysis of the operating principle and the mathematical model of Permanent Magnet Synchronous Liner Motor (PMSLM), a model of PMSLM double loop control system based on vector control is designed with Matlab/Simulink, and the model, a Current track - type PWM inverter model is given. Based on the double loop control system, an iterative learning control (ILC) method with a configuration of feedback is proposed to achieve precise tracking control of the PMSLM over a finite time interval. In the end, the ILC simulation and experiment research for the whole system are carried out. It is verified that ILC with composite control algorithm has a good performance in improving the position tracking ability of the PMSLM system by simulation and experiments results.

Fault Diagnosis based on Wavelet-Entropy Feature Extraction and Information Fusion
Mohammad Reza Vazifeh, Farzaneh Abassi
Wuhan University of Technology, China

It is important to reduce maintenance costs and prevent unscheduled downtimes for machinery. So knowledge of what, where and how faults occur is very important. Condition-based maintenance (CBM) has the potential to decrease life-cycle maintenance costs, increase operational readiness and improve safety. Fault detection and diagnosis are also necessary for implementing CBM. Best classifier systems are considered as one of the most significant advances in pattern classification in recent years. Numerous studies (both theoretical and empirical) have proved that are effective in achieving improved classification performance for various application problems. The failure of machinery reduces the production rate and increases the costs of production and maintenance. Therefore, it is important to reduce maintenance costs and prevent unscheduled downtimes for machinery. In this paper we present a new model for fault diagnosis. In this model we used multi feature extraction and information fusion and SVM classification, Multi-source classification methods based on Support Vector Machines and data fusion strategies are proposed in this paper. The centralized and distributed fusion schemes are applied to combine information from several data sources. In the centralized scheme, all information from several data sources is centralized to construct an input space. Then Information fusion strategies are proposed to combine the information from the individual multi-wavelet-Entropy models. Our proposed fusion strategies take into account that a Wavelet- Entropy by finding the optimal hyper plane with maximal margin. Then a Support Vector Machine classifier is trained. In the distributed schemes, the individual data sources are processed separately and modeled by using the Support
Vector Machine. Fault diagnosis is to detect, isolate, and assess malfunctions/faults and failures of engine system and its major components.

**Temperature Measurement Control Problem of Vibrational Viscometers Considering Heat Generation and Heat Transfer Effect of Oscillators**

Ali Akpek, Chongho Youn, Toshiharu Kagawa
Tokyo Institute of Technology, Japan

In viscosity measurement, temperature control is very important. In this research, temperature distribution effect of vibrational viscometers was analyzed. Vibrational viscometer was designated amongst other viscometer types due to inexpensiveness, handiness and efficacious continuous viscosity measurement capability. The research was conducted in three parts. In the first part; heat generation problem of boundary layers of oscillators of vibrational viscometers was analyzed. Experiments prove that due to the friction between the oscillators and the fluids, heat is generated from the vibrational boundary layer of the oscillators. In the second part, unequal temperature distribution problem of vibrational viscometers was analyzed. When heater generates heat during continuous viscosity measurement, temperature disperses every part of a fluid and affects the viscosity of the fluid. Therefore, it may not be possible to acquire a homogenous viscosity value from a fluid since temperature distribution cannot be equal at every point of a standard fluid. Experimental outcomes and mathematical calculations have also strengthened this conclusion. In the last part of the research, in order to solve the unequal temperature distribution problem, it is proposed to utilize a magnetic stirrer which will mix up the fluid throughout the viscosity measurement and constitute homogenous temperature.

**A New Approach Based on Boundary Analysis of Reconstructed Phase Space for Fault Diagnosis**

Ilhan Aydin, Mehmet Karakose, Erhan Akin
Fatih University, Turkey

This paper presents a new fault diagnosis approach based on boundary analysis of phase space. The proposed approach requires the measurement of one phase current signal to construct the phase space representation. Each phase space is converted to an image and the boundary of each image is extracted by boundary detection algorithm, helping to construct a characteristic image for each motor condition. The change in boundary of phase space appears to be a useful for diagnosing different motor operating conditions. A pattern recognition algorithm based on neural network is implemented to classify the faults. We will study one and two broken rotor bars faults. Extensive experimental results were carried out to validate the proposed approach, and good results were obtained.

**Exact-estimator-based Terminal Sliding Mode Control System Design**

Jeng-Dao Lee\(^1\), Suiyang Khoo\(^2\), Jia-Qi Lu\(^3\)
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This paper investigates an estimator-based terminal sliding mode control system. An exact estimator is proposed to exactly estimate the unknown uncertainties in finite time. The output of the exact estimator is used to design a continuous chattering free terminal sliding mode control. The time taken for the closed-loop system to reach zero tracking error is proven to be finite. Experiment results are presented, using a real time digital-signal-processor (DSP) based electromagnetic-levitation system to implement the control performance.

**An Algorithm of Decentralized Encircling Coverage and Termination of a Moving Deformable Region by Mobile Robotic Sensor/Actuator Networks**

Andrey V. Savkin\(^1\), Zhiyu Xi\(^1\), Hung T. Nguyen\(^2\)
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The paper introduces the problems of encircling coverage and termination of a moving a deformable planar region by a mobile sensor/actuator network. We propose a decentralized randomized algorithm for self-deployment of a network of mobile robotic sensors/actuators for these problems. In the encircling coverage problem, the aim is to deploy sensors around a bounded connected region so that any point of a certain neighbourhood of the region is sensed by at least one mobile robotic sensor. In the termination problem, the aim is to terminate a moving region that may represent an oil spill or a hazardous chemical field. In this case, the moving robots are equipped with not only sensors but with actuators releasing neutralizing chemical so that the shape of the polluted region is controlled. The proposed algorithm is based only on information about the closest neighbours of each sensor. The moving region is of an arbitrary shape and not known to the sensors a priori. We give mathematically rigorous proofs of asymptotic optimality and convergence with probability 1 of the proposed randomized algorithm.

**Locating WiFi Access Points in Indoor Environments using Non-monotonic Signal Propagation Model**

Saeed Varzandian, Hasan Zakeri, Sadjaad Ozgoli
Tarbiat Modares University, Iran

In this paper it is shown that the widely used log-normal path loss signal propagation model may not a good choice for every indoor environment. Instead, a non-monotonic signal propagation model for an indoor environment is presented. This model, combined with received signal strength values, relative distance and directional information can exhibit several applications. As an example, access point position estimation is studied in this paper and an algorithm is proposed for this purpose. It is shown that using relative distance, directional information and an arbitrary reference point, it is possible to...
find the relative location of access points. The performance of proposed model and algorithm is tested by real data and computer simulation.

A Sensory Data Tracking Approach to Bipedal Gait Compensation Control on Slope Surfaces
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National Chiao Tung University, Taiwan
The development of biped robots has gained much research attention in recent years due to their capacity and flexibility in providing assistance to human. In practical applications, these robots are expected to walk on various types of ground surfaces. Balance control of bipedal walking on uneven terrain is still a challenging problem. This paper proposes a novel gait compensating method using sensory data tracking such that a robot can keep balance and walk on slope surfaces. The real-time compensation control system works to adjust the gait and thus make online sensory data to track the stored target sensory data, which are obtained from the robot when it walks on a flat surface. While the robot adjusts its gait to make online sensory data similar to those on a flat surface, it will achieve a stable pose in walking. The proposed method has been tested for several slopes using the NAO robot. The robot can adjust its pose automatically on slope surface according to the proposed method. An experiment on transition slopes further validates that the method can be extended to more general terrain variations for biped walking.

Optimization Based Algorithm for Correction of Systematic Odometry Errors of Mobile Robot
Senka Krivic, Aida Mrzic, Jasmin Velagic, Nedim Osmic
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This paper deals with measuring and reduction of odometry errors of a differential-drive mobile robot. For this purpose an algorithm for reducing systematic odometry errors caused by uncertainty of an effective wheelbase and unequal wheel diameters is proposed. The algorithm calculates three calibration coefficients using an optimization based on Levenberg-Marquardt algorithm. These coefficients compensate the effects of unknown values of wheel radius and unknown value of the wheelbase. The mobile robot location during a motion is determined based on visual system measurements. For evaluating the proposed algorithm three different tests are considered: straight line experiment, turn in place experiments, uni-directional square path experiment. Simulation and experimental results demonstrate the effectiveness of the proposed algorithm in reducing the systematic odometry errors.

FA System Integration using Robotic Intelligent components
Young-Ho Choi, Jung-Woo Lee, Sung-Jo Yun, Jin-Ho Suh, Sung-Ho Hong, Jong-Deuk Lee
Korea Institute of Robot and Convergence, South Korea
This paper describes FA system integration procedure using Robotic Intelligent Components and the customized Open Software Platform for Robotic Services (OPRoS) component development tool which are the 4th year research results of our project, 『The development of Robotic Intelligent S/W Component and its performance test』. In our previous paper, we suggested a unified system integration method to build an intelligent robotic system using robotic intelligent components (RIC) and introduced the concept of a robotic intelligent component which consists of an embedded hardware module adopting EtherCAT bus and a software module based on Open Software Platform for Robotic Services (OPRoS) in the first paper and then we described the easy system integration procedure to develop a mobile manipulator using RIC in the second paper. In this paper, we address the FA system integration procedure using FA H/W module and S/W modules developed toward the commercialization and popularization of RIC. We expect that RIC is applicable to the industrial filed as well as the intelligent robotic field.

Detection and Control of a Wheeled Mobile Robot Based on Magnetic Navigation
Guan Sun, Dan Feng, You tong Zhang, Dongdong Weng
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This paper introduces the design of a wheeled mobile robot based on magnetic navigation. The working principle of magnetic navigation is analyzed, and a novel navigation path detection algorithm is proposed. Meanwhile, the fuzzy control algorithm and PID algorithm are combined to optimize the control performance of the steering servo and the electric motor. The experimental results show the effectiveness of both the detection and the control algorithm. The wheeled mobile robot can trace the navigation path automatically and precisely at a high speed.

Time-Varying Formation Control for Nonholonomic Wheeled Mobile Robots via Synchronization
Ibrahim M.H. Sanhoury, Shamsudin H.M. Amin, Abdel Rashid Husain
Universiti Teknologi Malaysia, Malaysia
In this paper, a new synchronous control law is proposed for multiple nonholonomic wheeled mobile robots (WMR) to perform a time-varying formation task. Each robot is controlled to track its desired trajectory, while synchronized its motion with the two adjoining robots. A novel dynamic model of the WMR is derived based on Lagrange method. The Lagrange multiplier of the WMR is determined based on the input torques and the robot’s velocities. The dynamic model has been divided into translational and rotational model. A synchronous translational controller is proposed to guarantee the asymptotic stability of both position and synchronization errors. A rotational controller is designed such that the robot always facing its desired position. A simulation results verified the effectiveness of the proposed synchronous controller in the formation tasks.
Localization of an Autonomous Underwater Vehicle Using a Decentralized Fusion Architecture

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In this paper, the position of an autonomous underwater vehicle (AUV) has been estimated using the data of two estimation loops via a decentralized data fusion algorithm. Extended Kalman Filter (EKF) is used in each local loop and a decentralized Information Filter is used to fuse the data obtained from the other loop. The sensors used in the loops are: loop 1) Doppler Velocity Log (DVL), rate gyros as internal sensors, and a pressure sensor and compass as the external sensor, loop 2) accelerometer, two inclinometer and Z-axis free gyro as internal sensors and echo sounder as the external sensor. AUV can be localized using each of the two estimation loops, but the decentralized architecture is more robust and leaves a degree of redundancy for checking possible faults of sensors and/or local estimation algorithms. The results show that despite the limitations in choices and arrangements of the sensors, the two local loops perform appropriately and the fusion of the estimates of the local loops improves the robustness of the estimates. At the end, the proposed decentralized architecture has been compared with a centralized algorithm and its advantages are pointed out.

Stereo Vision Based Robots: Fast and Robust Obstacle Detection Method

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In this paper we present a new obstacle detection method, based on stereo vision, without combination with any other kind of sensors. The proposed method uses a differential image transform algorithm to gain robustness against illumination changes. This method increases the speed of program execution while keeping the performance of stereo vision algorithm in term of accuracy in the same level with the previous algorithms. Moreover, we implement this method into a stereo vision based robot while adding some new features to widen the depth detection range. With the help of the proposed method, the robot detects obstacles between 25cm to 400cm from robot cameras. The result shows the robot has the ability to work in a wide variety of lighting conditions, while the stereo vision part of the robot does the depth detection computation with the speed of 30FPS.

Divergence-based Odor Source Declaration

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University of Coimbra, Portugal

This paper explores the use of the divergence operator for odor source declaration in swarm-based algorithms. A set of simulations of a swarm of robots running the decentralized asynchronous particle swarm optimization, bacterial foraging optimization and ant colony optimization algorithms was used to generate multiple wind and odor biased vector fields to investigate the effectiveness of the divergence operator in odor source declaration. A set of real world experiments were also performed using the same swarm algorithms on a controlled environment to ascertain if the divergence operator can also be used on real data. The sparse gas sensor data acquired by the robots was interpolated using the Nadaraya-Watson estimator by means of a wind and odor biased kernel before the application of the divergence. Results show that the divergence operator excels at odor source declaration.

Combating the Effects of Delay in Periodic-Review Perishable Inventory Systems

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The paper considers the problem of providing efficient control of periodic-review production-inventory systems with perishable goods and nonnegligible delivery time. The paper investigates formally the classical delay compensation mechanisms used in inventory control and shows deficiencies of inventory position and Smith predictor in the systems with deteriorating stock. Then, a new delay compensation mechanism is developed and nonlinear control law synthesized. The proposed control scheme is proved robust with respect to unpredictable demand and delay variations.

Malicious Data Injection Attack Against Power System State Estimation Based on Orthogonal Matching Pursuit

Chao Zhang, Aimin Zhang, Zhigang Ren, Yuanxin Zhang, Yingsan Geng
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State estimation is a critical power system component that estimates the state of the power network and deals with bad data, depending in general on a redundant set of meter measurements and network topology configuration. Recently, some researchers have constructed a new class of attack. They can successfully bypass the existing power system state estimation and inject bad data to the state variables, causing enormous threats to the power system. This paper investigates the methods to identifying the minimum number of meter measurements to compromise in launching such an attack, which is named least-effort malicious data injection attack. The traditional matching pursuit (MP) algorithm for identifying the meters requires a large number of iterations to reach convergence. A modified orthogonal matching pursuit (OMP) algorithm is therefore introduced. Comparison of the two methods in the simulation on standard IEEE test system indicates that the OMP algorithm compromises fewer meters than the MP algorithm in the same number of iterations.
Development of Power Add on Drive Wheelchair and Its Evaluation

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Recently, due to increasing aging population, there has been increased interest and demand for electric powered wheelchairs. However, generally, they are considerably large or heavy to be transported by a vehicle. In order to improve this problem, a power add-on drive wheelchair (PADW) has been developed by combining the advantages of a manual wheelchair and a powered wheelchair. In particular, a study of in-wheel motor has been an important issue to develop a light weight powered wheelchair since the volume and the weight of the wheelchair can be minimized by containing many mechanical elements such as motor, brake, reducers and etc. inside of a wheel hub. In this study, the design specification of a driving motor for a PADW is determined via modeling, and a light-weight wheelchair is developed by adopting an in-wheel motor that is detachable from the wheelchair and allows conversion between the manual and the powered modes freely. Further, through the various experiments, the performance of the developed PADW was evaluated.

Manual Control of Inverted Pendulum with Different Input from Joystick

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The cognitive behavior of human operators in human-machine system has long served as a compelling target for control theory. For this purpose, extensive research effort has been focused on the manual control of inverted pendulum, from which cognitive and motor behavior can be obtained. However, much less attention has been paid to the effect on this experimental platform with different input, e.g. force, velocity, position. With the intention to provide more interactive form between human operators and electromechanical systems, this manuscript gives a comparative study on a virtual pendulum system which is built based on OpenGL when different commands are provided with a joystick. All forms of dynamical models have been obtained through mathematical manipulation. In order to obtain more realistic effect, dynamical models are shoveled with Runge-kutta method. A joystick interface enables operators to control the pendulum manually, providing a fun experience. This study establishes the foundation for further research on cognitive behavior of human operators in human-machine interaction systems and neural control systems.

Modeling Overtaking Behavior in Virtual Reality Traffic Simulation System

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Overtaking behavior in traffic is complex and the traffic information is heterogeneous, current researches on virtual reality traffic simulation have paid little attention on modeling overtaking behavior, considering the different traffic situation. In this paper, an intelligent vehicle model is proposed to better understandings of traffic situation and to assist overtaking behaviors analysis in traffic simulation. Then overtaking behavior model based on the intelligent vehicle is introduced in detail, the lane changing behavior model is analyzed because it is the base of overtaking behavior. Besides, overtaking behavior is realized by the coordination mechanism of agent-based multi-controller, which incorporates different traffic situation to explore overtaking behavioral mechanism in traffic. The preliminary results show the effectiveness of our method to simulate overtaking behavior in virtual reality traffic simulation system.

Infinite horizon MPC applied to an industrial FCC converter

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This paper concerns the application of a closed-loop stable MPC to an industrial FCC converter. The nominal stability of the proposed controller is achieved by considering an infinite prediction horizon. In addition, the state-space model used in the controller formulation is derived from the analytical form of the step response associated with transfer function models of the process, which were obtained from real plant tests.

Duopolistic dynamics in markets with competitive advertising and churn

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This paper briefly surveys the different models that have been proposed for dynamics of duopolies with competitive advertising and churn. It also proposes a model that is capable of representing competitive advertising and churn, in a unified way for saturated and unsaturated markets. The objective is to carry out a qualitative analysis of the effect of different types of competitive advertising policies in the presence of churn. The proposed model can be seen as a generalization of duopolistic dynamic models that of the classical Vidale-Wolfe and Lanchester type, also including a model of churn. The firm with a perceived lower share of the market switches on an extra control effort in its attempt to get a larger share than its competitor. The main contributions are to show that the proposed approach can serve to explore whether or not it is worth entering a dispute for market share and, if so, what control strategies should be adopted. Furthermore, the effects of churn are studied systematically.
This paper proposes a new measurement based approach to solve synthesis problems in linear systems with applications to mechanical systems, hydraulic networks, civil engineering structures, etc. We show that few strategic measurements reveal the functional dependency of a desired system variable on the set of the design elements. Once the functional dependency is found, one can apply the design constraints to obtain the feasible set of values for the design elements.

Sensor/Actuator System for Internet Delays and Packet Losses
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University of Vigo, Spain

Network delays and packet losses are two critical parameters for the performance of networked control systems (NCS) in non-deterministic packet networks, such as the Internet. To avoid the need of a remote location, the laboratory experiences in teleoperation or telerobotics uses network simulators to reproduce the delays and packet losses. This paper presents an Internet emulation system that performs as a sensor of Internet delays and packet losses and as an actuator that reproduces these parameters into a local data flow. The paper presents some comparative results and makes a performance analysis of the whole system.

Faults Diagnosis of Induction Machine by Using Feed-Forward Neural Networks and Genetic Algorithms
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We present the results of our investigation in the use of the multilayer feed-forward artificial neural networks (ANNs) and genetic algorithms (Gas) for fault diagnosis of induction machine. ANNs are used effectively to determine the classification of the faults of induction machine tested at different loads and at different frequencies. The proposed methodology is tested experimentally on four 4kW/1500rpm induction machines. The obtained results provide a satisfactory level of accuracy.

Adaptive TSKCMAC-Identification-Based Intelligent Backstepping Control for Nonlinear Chaotic Systems
Ya-Fu Peng1, Chih-Hui Chiu2, Hsing-Yueh Cho3, Hsin-Min Wen1

1Chien Hsin University of Science and Technology, Taiwan; 2Yuan-Ze University, Taiwan

An adaptive Takagi-Sugeno-Kang type cerebellar model articulation controller (TSKCMAC)-identification-based intelligent backstepping control (ATCIBC) system is proposed for the nonlinear chaotic systems. This ATCIBC system is composed of an adaptive intelligent backstepping controller (AIBC) and a robust H∞ controller. The AIBC, which uses a TSKCMAC identifier to on-line estimate the controlled system dynamics, is the principal tracking controller. The robust H∞ controller is designed to attenuate the effect of minimum approximation error introduced by the TSKCMAC identifier and external disturbances with desired attenuation level. Moreover, all adaptation laws of the ATCIBC system are derived based on the Lyapunov stability analysis, backstepping control technique and H∞ control theory, so that the stability of the closed-loop system and H∞ tracking performance can be guaranteed. Finally, the proposed control system is applied to control a Genesio chaotic system. From the simulation results, it is verified that the proposed control scheme can achieve favorable tracking performance for these nonlinear systems.

Adaptive Sliding Mode Control Strategy Design for DSP-based Maglev Driving and Control System
Rou-Yong Duan1, Jeng-Dao Lee2, Ming-Jui Wu2

1Hungkuang University, Taiwan; 2National Formosa University, Taiwan

This paper investigates the robust tracking control problem for a bipolar electromagnetic-levitation precise-position system. The dynamic model of the precise-position device is derived by conducting a thorough analysis on the nonlinear electromagnetic forces. Conventional sliding mode control strategy is developed to guarantee asymptotic tracking capabilities of the closed-loop system. A lumped uncertainty estimator is proposed to estimate the system uncertainties. The estimated information is then used to construct a smooth uniformly bounded sliding mode control. Experiment results are presented, using a real time digital-signal-processor (DSP) based electromagnetic-levitation system to validate the analysis.

Cognitive Radio Networks for Smart Grid Communications
Fang Liu, Jinkuan Wang, Yinghua Han, Peng Han

Northeastern University, China

A critical component of smart grid is the integration of multiple communication technologies which can facilitate the development of smart grid. However, most of the traditional communication technologies cannot satisfy the critical and complex requirements of smart grid, such as, efficiency, reliability, resilience, sustainability, and security. In this paper, the cognitive radio (CR) technology is leveraged to construct the communication infrastructure of smart grid. First, ISM bands and leased bands are introduced as backup bands to ensure the QoS of data communications in CR based networks, for which a rule that decides when to stop spectrum sensing and access the ISM bands is also provided. Furthermore, a proper communication scheme is proposed for distributed generation system based on the fact that different renewable energy
source has different active period during a day. Some licensed bands whose idle time is in line with the active period of renewable energy sources are set aside exclusively for distributed generation system access. The two schemes improve both the efficiency of spectrum utilization and reliability of cognitive communications in smart grid.

A Model Predictive Control of Transparent Bilateral Teleoperation Systems Under Uncertain Communication Time-Delay
Seyyed Vahid Ghoushkhanehee, Alireza AlifiShahrood
Shahrood University of Technology, Iran

Performance and stability degradation in teleoperation systems experiencing time delay in both forward and backward channels is of crucial importance. What is addressed in this paper is to propose a new control strategy using a modified Model Predictive Control (MPC) and a modified smith predictor. The MPC is in charge of the forward communication time delay by providing future control sequences. Also, the smith predictor compensates for the backward time delay. First, as a slave controller a simple discrete PD controller is designed for the slave system. Then, the system is reduced to a more general form to derive the future control sequences or namely to derive the master controller. Throughout the paper a low-pass unitary gain filter is used to improve the robustness of the teleoperation system under study. The design of a pre-filter highly reduces the overshoots imposed on the system.

Sliding-Mode Control of a Wheeled Vehicle Using Neural Network Estimator
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A motion control problem of a rear-steered wheeled vehicle in consideration of the presence of uncertainties is addressed. Modeling error and additional uncertainties are taken into consideration. A sliding mode controller combining with a radial basis function neural network (RBFNN)-based estimator is proposed. The stability of the proposed control method is proven using Lyapunov stability analysis. Simulation results demonstrating the performance of the proposed control law are presented. It can be concluded that the driving velocity and steering angle performances of the proposed controllers are reasonably acceptable.
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