



5th IEEE MEDITERRANEAN CONFERENCE ON CONTROL AND SYSTEMS

Proceedings
on
CD-ROM

Phaethon Beach Sunhotel
Paphos, Cyprus
July 21-23, 1997

THE 5TH IEEE MEDITERRANEAN CONFERENCE
ON CONTROL AND SYSTEMS

Phaethon Beach Sunotel, Paphos, Cyprus
July 21-23, 1997

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THE 5TH IEEE MEDITERRANEAN CONFERENCE
ON CONTROL AND SYSTEMS

Phaethon Beach Sunotel, Paphos, Cyprus
July 21-23, 1997

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IEEE MED STEERING COMMITTEE

Panos Antsaklis, Manolis Christodoulou, Theodore Djaferis, Peter Groumpos, Petros Ioannou, Frank Lewis, Kimon Valavanis

1. WELCOME

On behalf of the Organizing and Program Committees, I welcome you to Cyprus and the 5th IEEE Mediterranean Conference on Control and Systems (5th IEEE MED). I hope that your trip to Paphos was uneventful and that you are eager to participate in an exciting technical meeting. We cannot, of course, forget that we are on Cyprus, an island with rich history, natural beauty and legendary hospitality. Therefore, my hope is that you will also have the opportunity to relax and enjoy all that Cyprus has to offer. After all, we should not “offend” the ancient Greek inhabitants of the island who used to live by the saying: το τερπνον μετὰ του ωφελιμου, which loosely translates to: business with pleasure.

The 1997 Mediterranean Conference on Control and Systems, is the 5th such meeting held in the Mediterranean and the second held in Cyprus. It is co-sponsored by the IEEE Control Systems Society, the University of Cyprus, The Technical Universities of Crete and Patras, the IEEE Cyprus Section, the IEE Cyprus Section and the IEEE Greek Chapter of the Control Systems Society.

The Conference is truly an international event, that attracted the attention of researchers in the field from all over the world. Authors are representing more than twenty countries and come from five continents. The technical program consists of 129 contributed and special session papers, which are arranged in 24 sessions. These papers will be presented over three days, Monday, Tuesday and Wednesday, July 21, 22 and 23 respectively. Each day is divided into morning sessions (four parallel sessions) and afternoon sessions (four parallel sessions). The topics range from Hybrid and Intelligent Systems to Robust and Adaptive Control, Automotive Systems and Digital Signal Processing. The Conference Plenary Lecture is:

Monday morning at 8:30

Professor Sanjoy Mitter of the Massachusetts Institute of Technology
Logic, Mathematical Programming and Hybrid Systems

A brief biography of the plenary speaker can be found below.

The Conference Proceedings will be published on CD-ROM, which is a first for the MED Conference. This is in response to the trend in conference publications of recent years. This medium offers expanded search capabilities for conference proceedings readers and is arguably a more efficient method to disseminate information. Most of the papers included in the CD-ROM were submitted to the CD-ROM producer electronically. In addition to the CD-ROM, each conference participant will receive a hardcopy Conference Program which includes a Book of Abstracts.

The planning, organization and running of this Conference, was done exclusively by volunteers. Without their tireless efforts this Conference would not run smoothly. I would like to give special thanks to Petros Ioannou, for handling finances, registration, hotel arrangements and special events. Many thanks go to Vassilis Syrmos, the Publicity Chair and the members of the Program Committee who helped with reviews. Thanks also go to Orhan Beker, for his help in producing the Book of Abstracts. Most importantly, many thanks go to the organizers of special sessions and all the authors, who have made this Conference a reality. Finally, let me also thank all attendees, who with their participation have ensured the success of the 5th IEEE MED.

Theodore E. Djaferis
General/Program Chair, 5th IEEE MED

2. CONFERENCE REGISTRATION

Most of the Conference attendees have pre registered for the Conference. All who pre registered are asked to go to the Conference Registration Desk, in order to obtain conference related material and publications. Those of you who chose to register on site are urged to do so as quickly as possible. The Conference Registration Desk will be open the following hours:

Sunday July 20, 6:30 p.m. to 8:30 p.m.

Monday July 21, 7:00 a.m. to 10:00 a.m. and 12:00 p.m. to 2:00 p.m.

The registration fee covers admission to all technical sessions, opening reception, coffee breaks and the gala dinner. Each registrant will also receive a copy of the Conference Program (which includes the Book of Abstracts) and one CD-ROM with the Conference Proceedings. Conference registrants may purchase additional sets of CD-ROM Proceedings at the Registration Desk for \$40 (20 Cyp. Pounds) each.

3. SOCIAL EVENTS

- Opening Reception (7:00 PM, Sunday, July 20)

On Sunday, July 20, 1997, there will be an opening reception held at the Phaethon between 7:00 p.m. and 9:00 p.m. This will give the opportunity to Conference participants to meet and socialize.

- Gala Dinner (8:00 PM, Tuesday, July 22)

On Tuesday, July 22, 1997, starting at 8:00 p.m. the evening Gala Dinner will take place at the taverna Demokritos. This is located within walking distance from the Phaethon and directions will be provided at the Conference Registration desk. Extra tickets for the gala dinner cost \$25 (7.5 Cyp. Pounds) each.

4. ABOUT CYPRUS AND PAPHOS

The island of Cyprus, is located in the north-eastern corner of the Mediterranean sea, about 200 miles east of the island of Rhodes, 60 miles west from Syria, 250 miles north of Egypt and 40 miles south of Turkey. In size it is the third largest island in the Mediterranean, after Sicily and Sardinia, with an area of 3,572 square miles (9,251 square kilometers). Its greatest breadth from north to south is 60 miles and its greatest length from east to west is 140 miles. The most prominent topographical features of the island are two mountain ranges, Pendadaktylos (in Greek it means “five fingers”) to the north and Troodos to the south, separated by the wide central plane Mesaoria (in Greek it means “between mountains”). The highest peak (6,401 feet) is in the Troodos range and is called Mount Olympus (or Chionistra). Average annual rainfall is about 19 inches, with the summer months being quite dry and hot.

The civilization of Cyprus dates back to the 7th millennium B.C., beginning with the Neolithic Age (5800-3000 B.C.). Its beauty, resources and strategic location have been sought after by friendly visitors and conquerors alike for thousands of years. Their passing have shaped its history, culture and civilization and evidence of their presence can be found in the literally hundreds of archeological sites throughout the island. Its Greek heritage can be traced back three and a half thousand years to Mycenaean settlers. Archeological excavations have brought to light finds of all kinds: stone and bronze tools, utensils, weapons, precious stones, gold silver coins, rings and bracelets, marble and bronze statues, etc.. Many are exhibited in the Cyprus Museum in Nicosia (the capital) and at museums at other parts of the world. One can see “history” everywhere on the island, remains of ancient cities, temples, theaters, gymnasia, palaces, mosaics, Byzantine churches and monasteries with fresco paintings, mediaeval crusader cathedrals, castles and walled cities, tekkes, aqueducts, etc..

Paphos, the Conference site, is located on the west coast of Cyprus. It was founded in the fourth century BC and was the capital of Cyprus during Roman times. Places of interest in Paphos include: The Harbor, first built in the time of Alexander the Great, rebuilt in 1592 A.D.; St. Paul's Pillar to which St. Paul was tied and scourged; the Tombs of the Kings; the mosaics of the 3rd century A.D. which are the finest in the Mediterranean. Nearby, is Petra tou Romiou where according to legend Aphrodite emerged from the waves, and the Temple of Aphrodite. In addition to its rich history and archeological sites Paphos has some of the best beaches in Cyprus.

5. ON THE RECORD

The 1997 IEEE Mediterranean Conference on Control and Systems is the 5th such meeting held in this region of the world. Even though it is relatively “young” conference it nevertheless consistently attracts leading researchers in the area of Control and Systems from all over the world. The first, was held in 1993 and plans already exist for a number of future meetings: 6th IEEE MED Sardinia, Italy (1998); 7th IEEE MED Haifa, Israel; 8th IEEE MED Porto, Portugal; 9th IEEE MED Patras, Greece; 10th IEEE MED Barcelona, Spain. Listed below are the past and present IEEE MEDs.

1st IEEE MEDITERRANEAN SYMPOSIUM ON NEW DIRECTIONS IN CONTROL THEORY AND APPLICATIONS

June 21-23, 1993, Chania, Crete, Greece

General Chairman: M. A. Christodoulou

2nd IEEE MEDITERRANEAN SYMPOSIUM ON NEW DIRECTIONS IN CONTROL AND AUTOMATION

June 19-21, 1994, Chania, Crete, Greece

General Chairman: K. P. Valavanis

3rd IEEE MEDITERRANEAN SYMPOSIUM ON NEW DIRECTIONS IN CONTROL AND AUTOMATION

July 11-13, 1995, Limasol, Cyprus

General Chairman: P. A. Ioannou

Program Chairman: F. L. Lewis

4th IEEE MEDITERRANEAN SYMPOSIUM ON NEW DIRECTIONS IN CONTROL AND AUTOMATION

June 10-13, 1996, Chania, Crete, Greece

General Chairman: F. L. Lewis

Program Co-Chairs: K. Kyriakopoulos and P. G. Voulgaris

5th IEEE MEDITERRANEAN CONFERENCE ON CONTROL AND SYSTEMS

July 21-23, 1997, Paphos, Cyprus

General and Program Chairman: T. E. Djaferis

6. BIOGRAPHY OF THE PLENARY SPEAKER

Sanjoy Mitter received his Ph.D. degree from the Imperial College of Science and Technology, University of London, in 1965. He had previously worked as a research engineer at Brown Boveri & Co. Ltd., Switzerland (now ASEA Brown Boveri) and Battelle Institute in Geneva, Switzerland. He taught at Case Western Reserve from 1965 to 1969 and joined MIT in 1969 first as a Visiting Professor and then in 1970 as Associate Professor in the Department of Electrical Engineering and Computer Science. He is currently Professor of Electrical Engineering and Co-Director of the Laboratory for Information and Decision Systems. He is also Director of the Center for Intelligent Control Systems, an inter-university (Brown-Harvard-MIT) center for research on the foundations of intelligent systems. He has held visiting positions at the Tata Institute of Fundamental Research, Bombay, India; Scuola Normale Superiore, Pisa, Italy; Imperial College of Science and Technology; Institut National de Recherche en Informatique et en Automatique, France; University of Groningen, the Netherlands and several universities in the United States.

Professor Mitter's research has spanned the broad areas of Systems, Communication and Control. Although his primary contributions have been on the theoretical foundations of the field, he has also contributed to significant engineering applications, notably in the control of interconnected power systems and automatic recognition and classification of electrocardiograms. His current research interests are theory of stochastic dynamical systems, nonlinear filtering, stochastic and adaptive control; mathematical physics and its relationship to system theory; image analysis and computer vision; and structure, function and organization of complex systems.

Professor Mitter has served on several advisory committees and editorial boards for IEEE, SIAM, AMS, NSF and ARO. He is currently Associate editor of *Acta Applicandae Mathematicae*; *Circuits, Systems and Signal Processing*; *Journal of Applied Mathematics and Optimization*; *SIAM Review*; and the *Ulam Quarterly*. He is a fellow of the IEEE. In 1988 he was elected to the National Academy of Engineering.

5TH IEEE MEDITERRANEAN CONFERENCE ON CONTROL AND SYSTEMS

PROGRAM AT A GLANCE

MONDAY				
Plenary Talk: Sanjoy Mitter Logic, Mathematical Programming and Hybrid Systems Chariot 8:20am				
Track	1	2	3	4
Room	Chariot	Apollo	Zeus	Lindos
MA 10:00 to 12:00	MA1 Hybrid Systems	MA2 Stochastic Systems	MA3 Modeling Estimation and Control of Infinite Dimens. Systems I	MA4 Digital Signal Process. I
MP 1:30 to 4:30	MP1 Discrete Event Systems	MP2 Nonlinear and Stochastic Control: Theory and Applic.	MP3 Modeling Estimation and Control of Infinite Dimens. Systems II	MP4 Control of Automot. Engines and Drivelines

5TH IEEE MEDITERRANEAN CONFERENCE ON CONTROL AND SYSTEMS

PROGRAM AT A GLANCE

TUESDAY				
Track	1	2	3	4
Room	Chariot	Apollo	Zeus	Lindos
TA 9:00 to 12:30	TA1 Intelligent Systems	TA2 Robust Systems I	TA3 Modeling Estimation and Control of Infinite Dimens. Systems III	TA4 Mobile Robots
TP 1:30 to 4:30	TP1 Max-Algebra	TP2 Robust Systems II	TP3 Linear Systems I	TP4 Robot Control
Evening Gala Taverna Demokritos 8:00 PM				

5th IEEE MEDITERRANEAN CONFERENCE ON CONTROL AND SYSTEMS

PROGRAM AT A GLANCE

WEDNESDAY				
Track	1	2	3	4
Room	Chariot	Apollo	Zeus	Lindos
WA 9:00 to 12:30	WA1 Nonlinear Systems	WA2 Applications	WA3 Linear Systems II	WA4 Automot. Systems
WP 1:30 to 4:30	WP1 Two-Dimens. Systems	WP2 Adaptive Control	WP3 Linear Systems III	WP4 Digital Signal Process. II

5th IEEE MEDITERRANEAN CONFERENCE ON CONTROL AND SYSTEMS

Monday, July 21

Chariot

Opening Remarks
8:20

Plenary Lecture
8:30-9:30

Logic, Mathematical Programming and Hybrid Systems
Sanjoy K. Mitter

Massachusetts Inst. of Tech.

Chair: Theodore E. Djaferis,
Co-Chair: Petros Ioannou,

Univ. of Massachusetts Amherst
Univ. of Southern California

Chariot		Apollo	
MA1		MA2	
Hybrid Systems		Stochastic Systems	
Chair: J. B. Remmel	Sagent Corporation	Chair: C. D. Charalambous	McGill Univ.
Chair: C. Panayiotou	Univ. of Massachusetts Amherst	Chair: R. P. Malhame	Ecole Polytech. de Montreal
10:00		10:00	
<i>Automaton Comparison Procedure for the Verification of Hybrid Systems</i>		<i>Estimation of Hidden Markov Models for Partially Observed Risk Sensitive Control Problems</i>	
Wolf Kohn	Sagent Corporation	Bernard Frankpitt	Univ. of Maryland
Jeffrey B. Remmel	Sagent Corporation	John Baras	Univ. of Maryland
Anil Nerode	Cornell Univ.		
10:30		10:30	
<i>A Hybrid Systems Approach to Feedback Control of a Nonholonomic Vehicle</i>		<i>Linear Gaussian Quadratic Regulation Under Poisson Distributed Intermittent State Observations</i>	
J. Almeida	DEEC Univ. do Porto	M. Ades	McGill Univ.
F. Lobo Pereira	DEEC Univ. do Porto	P. E. Caines	McGill Univ.
J. Borges Sousa	DEEC Univ. do Porto	R. P. Malhame	Ecole Polytech. de Montreal
11:00		11:00	
<i>Discrete Levels Control of Nonlinear Systems</i>		<i>Finite-Dimensionality of Information States in Optimal Control of Stochastic Systems</i>	
Photis G. Skiadas	Univ. of Patras	Charalambos D. Charalambous	McGill Univ.
Nick T. Koussoulas	Univ. of Patras		
11:30		11:30	
<i>A Framework for Hybrid Control Design and its Relations with a Class of Fuzzy Control Systems</i>		<i>Tracking Changing Stochastic Models via Stochastic Binary Neural Networks</i>	
R. Fiero	Univ. of Texas Arlington	Anthony Burell	Univ. of Alabama
F. L. Lewis	Univ. of Texas Arlington	Achilles Kogiantis	Univ. of Southwestern Louisiana
K. Liu	Univ. of Texas Arlington	P. Papantoni-Kazakos	Univ. of Alabama

Zeus		Lindos	
MA3		MA4	
Modeling Estimation and Control of Infinite Dimensional Systems I		Digital Signal Processing I	
Chair: M. A. Demetriou	Worcester Polyt. Inst.	Chair: J. A. Stuller	Univ. of Missouri-Rolla
Chair: S. Reich	Technion-Israel Inst. of Tech.	Chair: T. Kasparis	Univ. of Central Florida
Org: H. T. Banks	North Carolina State Univ.		
Org: M.. A. Demetriou	Worcester Polyt. Inst.		
10:00		10:00	
<i>Spay Control</i>		<i>Algorithms for Phase Acquisition for QAM Constellations</i>	
A. El Jai	Univ. of Perpignan	Costas N. Georgiades	Texas A & M Univ.
10:30		10:30	
<i>Estimation and Control of Sample-Data Systems in Infinite Dimensions</i>		<i>Maximum Likelihood Estimation of Scale</i>	
Akira Ichikawa	Shizuoka Univ.	John A. Stuller	Univ. of Missouri-Rolla
11:00		11:00	
<i>Fault Accommodation of Output-Induced Actuator Failures for a Flexible Beam with Collocated Input and Output</i>		<i>A Novel BPSK Demodulator Using the Expectation Maximization Algorithm</i>	
Michael A. Demetriou	Worcester Polyt. Inst.	Takis Kasparis	Univ. of Central Florida
Marios M. Polycarpou	Univ. of Cincinnati	Gregory Powell	Koos Tech. Services
11:30		11:30	
<i>Sampled Weighted Attraction Control of Distributed Thermal Scan Welding</i>		<i>A New Phase Model for Sinusoidal Coding of Speech Signals</i>	
Charalambos C. Doumanidis	Tufts Univ.	Sassan Ahmadi	Arizona State Univ.
		Andreas Spanias	Arizona State Univ.

	Chariot		Apollo
MP1		MP2	
Discrete Event Systems		Nonlinear and Stochastic Control: Theory and Application	
Chair: C. G. Cassandras	Boston Univ.	Chair: A. Lindquist	Royal Inst. of Tech.
Chair: M. A. Christodoulou	Tech. Univ. of Crete	Chair: C. F. Martin	Texas Tech Univ.
		Org: A. Lindquist	Royal Inst. of Tech.
		Org: C. F. Martin	Texas Tech Univ.
1:30		1:30	
<i>Supervisory Control Using Computationally Efficient Linear Techniques: A Tutorial Introduction</i>		<i>Dynamic Vision and Estimation Theory on Spheres</i>	
John O. Moody	Univ. of Notre Dame	Giorgio Picci	Univ. di Padova
Panos J. Antsaklis	Univ. of Notre Dame		
2:00		2:00	
<i>Dynamic Resource Allocation in Discrete Event Systems</i>		<i>Generalized Wiener-Hopf Factorization of Discrete-Time All-Pass Functions</i>	
Christos G. Panayiotou	Univ. of Massachusetts Amherst	Gyorgy Michaletzky	Eotvos Lorand Univ.
Christos G. Cassandras	Boston Univ.		
2:30		2:30	
<i>Dynamic Neural Networks for Real-Time Manufacturing Cell Scheduling</i>		<i>Observers for Systems with Implicit Output</i>	
George A. Rovithakis	Tech. Univ. of Crete	A. Matveev	St. Petersburg Univ.
Vassilis I. Gaganis	Tech. Univ. of Crete	X. Hu	Royal Inst. of Tech.
Stelios E. Perrakis	Tech. Univ. of Crete	R. Frezza	Univ. di Padova
Manolis A. Christodoulou	Tech. Univ. of Crete		
3:00		3:00	
<i>A State Reconstruction Algorithm for Parameter Dependent Discrete Event Dynamic Systems</i>		<i>On the Covariance Extension Problem</i>	
Francesco Martinelli	Univ. di Roma Tor Vergata	Christopher I. Byrnes	Washington Univ.
Salvatore Nicosia	Univ. di Roma Tor Vergata	Anders Lindquist	Royal Inst. of Tech.
Paolo Valigi	Univ. di Roma Tor Vergata		
3:30		3:30	
<i>A Model for Two-stage Manufacturing Systems</i>		<i>Cross-Ratio Dynamics and its Applications to Calibration Free Motion Estimation</i>	
Wai Ki Ching	Hong Kong Polyt. Univ.	Bijoy K. Ghosh	Washington Univ.
		4:00	
		<i>Control of the Planar Rotation in Human Head-Eye-Coordination</i>	
		Mangus Egerstedt	Royal Inst. of Tech.
		Clyde F. Martin	Texas Tech Univ.

Zeus**MP3****Modeling Estimation and Control of Infinite Dimensional Systems II**

Chair: C. D. Charalambous McGill Univ.
Chair: S. Reich Technion-Israel Inst. of Tech.
Org: H. T. Banks North Carolina State Univ.
Org: M. A. Demetriou Worcester Polyt. Inst.

1:30

Inverse Problems for Nonautonomous Nonlinear Distributed Parameter Systems

A. S. Ackleh Univ. of Southwestern Louisiana
S. Reich Technion-Israel Inst. of Tech.

2:00

A Conservative Spectral Element Method for the Approximation of Compressible Fluid Flow

Kelly Black Univ. of New Hampshire

2:30

Adaptive Identification of Distributed Parameter Systems

Yuri Orlov CICESE
Joseph Bentsman Univ. of Illinois Urbana-Champaign

3:00

Parameter Estimation in a Nonlinear Structured Tree Population Model with Self Shading Effects

A. S. Ackleh Univ. of Southwestern Louisiana

1:30

Automated Design of an Air/Fuel Controller for an SI Engine Considering the Three-way Catalytic Converter in the Hinf Approach

C. A. Roduner ETH Swiss Fed. Inst. of Tech.
C. H. Onder ETH Swiss Fed. Inst. of Tech.
Hans. P. Geering ETH Swiss Fed. Inst. of Tech.

2:00

Feedback Linearization of a Multi-Input SI-Engine System for Idle Speed Control

R. Pfiffner ETH Swiss Fed. Inst. of Tech.
Lino. Guzzella ETH Swiss Fed. Inst. of Tech.

2:30

Influence of Manifold Pressure Pulsation to Mean Value Models in Air-to-Fuel Ratio Control

M. Scherer Daimler-Benz AG
C. Arndt Univ. of Siegen
O. Loffeld Univ. of Siegen

3:00

Modelling Internal Combustion Engines via Identification Techniques

R. Scattolini Univ. di Pavia
G. De Nicolao Univ. di Pavia
M. Cittadini Univ. di Pavia
C. Rossi Magneti Marelli SpA
C. Siviero Magneti Marelli SpA

3:30

Identification of Emission Models in a Spark Ignition Engine for Control Applications

I. Arsie Univ. di Salerno
C. Pianese Univ. di Salerno
G. Rizzo Univ. di Salerno

Lindos**MP4****Control of Automotive Engines and Drivelines**

Chair: H. P. Geering ETH Swiss Fed. Inst. of Tech.
Chair: L. Guzzella ETH Swiss Fed. Inst. of Tech.
Org: H. P. Geering ETH Swiss Fed. Inst. of Tech.
Org: L. Guzzella ETH Swiss Fed. Inst. of Tech.

4:00

Advanced System Design and Control Aspects in a Fuel-Optimal Hybrid Vehicle

E. Shafai ETH Swiss Fed. Inst. of Tech.
P. Dietrich ETH Swiss Fed. Inst. of Tech.
C. Wittmer ETH Swiss Fed. Inst. of Tech.
S. Ginsburg ETH Swiss Fed. Inst. of Tech.

5th IEEE MED

Tuesday, July 22

		Chariot	
TA1			
Intelligent Systems			
Chair: K. P. Valavanis	Univ. of Southwestern Louisiana		
Chair: P. P. Groumpos	Univ. of Patras		
9:00			11:30
<i>A State Configured Sensor Based Control Architecture for an Autonomous Underwater Vehicle</i>			<i>On the Selection of Nodes in Linear-in-the-Weight Neural Networks</i>
Georgios. A. Demetriou	Univ. of Southwestern Louisiana	Elias B. Kosmatopoulos	Univ. of Southern California
Kimion P. Valavanis	Univ. of Southwestern Louisiana	Nikitas J. Dimopoulos	Univ. of Victoria
9:30			12:00
<i>The Use of Fuzzy Cognitive Maps in Modeling Systems</i>			<i>A Simplex Trained Neural Network-Based Architecture for Sensor Fusion and Tracking of Target Maneuvers</i>
Chrysostomos D. Stylios	Univ. of Patras	Yee Chin Wong	Univ. of Arizona
Voula C. Georgopoulos	Ohio Univ.	Malur K. Sundareshan	Univ. of Arizona
Peter P. Groumpos	Univ. of Patras		
10:00			
<i>Fuzzy Linear Programming and Simulated Annealing</i>			
Rita Almeida Ribeiro	Univ. Nova Lisboa		
Fernando Moura Pires	Univ. Nova Lisboa		
10:30			
<i>State Estimation in Presence of Disturbance Using Neural Networks</i>			
B. Gaddouna Ouladsine	Univ. Henri Poincare		
Gerard Bloch	Univ. Henri Poincare		
11:00			
<i>On-Line Neural Network Algorithm for the Constrained Motion Planning of Redundant Manipulators</i>			
A. Ramdane-Cherif	Univ. P. & M. Curie		
D. Y. Meddah	Univ. P. & M. Curie		
V. Perdereau	Univ. P. & M. Curie		
M. Drouin	Univ. P. & M. Curie		

Apollo		Zeus	
TA2		TA3	
Robust Systems I		Modeling Estimation and Control of Infinite Dimensional Systems III	
Chair: A. H. Sayed	Univ. of California Los Angeles	Chair: C. D. Charalambous	McGill Univ.
Chair: M. Karkoub	Kuwait Univ.	Chair: S. Reich	Technion-Israel Inst. of Tech.
9:00		Org: H. T. Banks	North Carolina State Univ.
<i>The Finite Inclusions Theorem: A Tool for Robust Design</i>		Org: M. A. Demetriou	Worcester Polyt. Inst.
Theodore E. Djaferis	Univ. of Massachusetts Amherst	9:00	
9:30		<i>Optimal Location of Actuators for an Active Noise Control Problem</i>	
<i>Every Mode Stabilization of Jump Linear Systems via LMIs</i>		F. Fahroo	Naval Postgraduate School
M. Ait Rami	Ecole Nat. Sup. de Tech. Avancees	9:30	
10:00		<i>Minimax Hinf Control of Stable Distributed Systems</i>	
<i>Robust Diagonal Stabilization and Finite Precision Problem: An LMI Approach</i>		O. Staffans	Abo Akademi Univ.
Stephane Dussy	Ecole Nat. Sup. de Tech. Avancees	10:00	
10:30		<i>Conditional Moment Generating Functions for Integrals and Stochastic Integrals: Maximum-Likelihood Estimation</i>	
<i>Robust Quasi NID Aircraft 3D Fight Control Under Sensor Noise</i>		Charalambos. D. Charalambous	McGill Univ.
Marian J. Blachuta	Silesian Tech. Univ.	10:30	
Valery D. Yurkevich	Novosibirsk State Tech. Univ.	<i>Ergodic Boundary Control of Semilinear Systems</i>	
Konrad Wojciechowski	Silesian Tech. Univ.	T. E. Duncan	Univ. of Kansas
11:00			
<i>Modeling And mu-Synthesis Robust Control of Two-Link Flexible Manipulators</i>			
Mansour Karkoub	Kuwait Univ.		
Kumar Tamma	Univ. of Minnesota		
11:30			
<i>Exponentially-Weighted Iterative Solutions for Worst-Case Parameter Estimation</i>			
Ali H. Sayed	Univ. of California Los Angeles		
Andrea Garulli	Univ. di Siena		
V. Nascimento	Univ. of California Los Angeles		
S. Chandrasekaran	Univ. of California Santa Barbara		
12:00			
<i>Some Issues on Robust Control for Nonlinear Systems</i>			
Michael Athans	Massachusetts Inst. of Tech.		
Alan Chao	Massachusetts Inst. of Tech.		

		Lindos	12:00
TA4			<i>Practical Stability for Path-Following: A New Control Algorithm for Mobile Robots</i>
Mobile Robots			T. Hamel Univ. de Tech. de Compiègne
Chair: P. Valigi	Univ. di Roma Tor Vergata	P. Soueres	LAAS-CNRS
Chair: T. Hamel	Univ. De Tech. De Compiègne	D. Meizel	Univ. de Tech. de Compiègne
9:00			
<i>A Robust-Adaptive Locomotion Controller for 9-Link Biped with Rapidly Varying Unknown Parameters</i>			
S. G. Tzafestas	National Tech. Univ. Athens		
A. E. Krikochoritis	National Tech. Univ. Athens		
C. S. Tzafestas	Univ. P. & M. Curie		
9:30			
<i>An Assessment of Fuzzy Logic for Collision Avoidance in a Multiple Autonomous Mobile Robot System</i>			
Chris G. Dodds	The Univ. of Western Australia		
Albert Y. Zomaya	The Univ. of Western Australia		
10:00			
<i>Steering of a Robotic Snake</i>			
K. Sarrigeorgides	National Tech. Univ. Athens		
K. J. Kyriakopoulos	National Tech. Univ. Athens		
10:30			
<i>Motion Planning for Drift-Free Nonholonomic Systems Under a Discrete Levels Control Constraint</i>			
Photis G. Skiadas	Univ. of Patras		
Nick T. Koussoulas	Univ. of Patras		
11:00			
<i>Dynamic Modelling of a Tricycle Mobile Robot</i>			
Andre Kamga	Univ. de Picardie Jules Verne		
11:30			
<i>A Navigation System With Self-Localization Capabilities for an Autonomous Mobile Robot</i>			
Alain Betourne	Univ. di Roma Tor Vergata		
Alessandro Fefe	Univ. di Roma Tor Vergata		
Salvatore Nicosia	Univ. di Roma Tor Vergata		
Paolo Valigi	Univ. di Roma Tor Vergata		

	Chariot		Apollo	
TP1			TP2	
Max-Algebra			Robust Systems II	
Chair: Y. Wardi	Georgia Inst. of Tech.		Chair: R. Hernandez-Berlinches	UNED
Chair: E. W. Kamen	Georgia Inst. of Tech.		Chair: E. Zeheb	Technion-Israel Inst. of Tech.
Org: E. Wagneur	IRCyN/Ecole des Moines de Nantes			
1:30			1:30	
<i>Linear Projectors in the Max-Plus Algebra</i>			<i>Robust Stability Analysis of GPC: An Application to Dead-Beat and Mean-Level Predictive Controllers</i>	
Guy Cohen	INRIA		Roberto Hernandez-Berlinches	UNED
Stephane Gaubert	INRIA			
Jean-Piere Quadrat	INRIA			
2:00			2:00	
<i>Equivalence Classes of Rank-3 Matrices in the Max-Algebra</i>			<i>Robust Stability of Non-Linear Time Varying Systems</i>	
Jean-Michel Prou	IRCyN/Ecole des Moines de Nantes		Ezra Zeheb	Technion-Israel Inst. of Tech.
Edouard Wagneur	IRCyN/Ecole des Moines de Nantes			
2:30			2:30	
<i>Control Synthesis Approaches Using the State Equations and the ARMA Model in Timed Event Graphs</i>			<i>Constrained Stabilization of a Dynamic System: A Case Study</i>	
Philippe Declerck	ISTIA		Franco Blanchini	Univ. degli Studi di Udine
			S. Cotterli	Eurotech
			G. Koruza	Univ. degli Studi di Udine
			S. Miani	Univ. degli Studi di Padova
			R. Siagri	Eurotech
			L. Tubaro	Univ. degli Studi di Udine
3:00			3:00	
<i>Dynamic Control of Kanban System Over Dioid Algebra</i>			<i>Robust and Reliable Hinf Output Feedback Control for Linear Systems With Parameter Uncertainty and Actuator Failure</i>	
B. Cottenceau	LISA		Chang-Jun Seo	Inje Univ.
L. Hardouin	LISA		Byung Kook Kim	KAIST
J.-L. Boimond	LISA			
3:30			3:30	
<i>Reachability and Observability of Linear Systems Over Max-Plus</i>			<i>Quadratic Stabilizability of Uncertain Continuous-Time Systems Under State and Control Constraints in the Presence of Disturbances</i>	
M. J. Gazarik	Georgia Inst. of Tech.		H. X. de Araujo	LAAS-CNRS
Edward. W. Kamen	Georgia Inst. of Tech.		I. Queinnec	LAAS-CNRS
			S. Tarbouriech	LAAS-CNRS
4:00			4:00	
<i>Controllability in the Max-Algebra</i>			<i>Delay-Dependent Robust Stability Tests and Decay Estimates for Systems With Input Delays</i>	
Jean-Michel Prou	IRCyN/Ecole des Moines de Nantes		Kostas Hrissagis	Univ. of Florida, Gainesville
Edouard Wagneur	IRCyN/Ecole des Moines de Nantes		Olga I. Kosmidou	Democritus Univ. of Thrace
4:30				
<i>Nonexpansive Maps and Option Pricing Theory</i>				
Vassili Kolokoltsov	Nottingham Trent Univ.			

Zeus		Lindos	
TP3		TP4	
Linear Systems I		Robot Control	
Chair: M. Sebek	Inst. of Inform. Theory and Autom.	Chair: A. Tornambe	Terza Univ. di Roma
Chair: C. N. Hadjicostis	Massachusetts Inst. of Tech.	Chair: P. S. Shiakolas	Univ. of Texas Arlington
1:30		1:30	
<i>Transfer Function Equivalence of Feedback/Feedforward Compensators</i>		<i>Global Asymptotic Stabilisation of an Active Mass Damper for a Flexible Beam</i>	
Vladimir Kucera	Academy of Sciences of the Czech Rep.	Laura. Menini	Univ. di Roma Tor Vergata
		Antonio. Tornambe	Terza Univ. di Roma
		L. Zaccarian	Terza Univ. di Roma
2:00		2:00	
<i>Numerical Operations Among Rational Matrices: Standard Techniques and Interpolation</i>		<i>Variable Structure Control of a Robotic Assistance System</i>	
P. Husek	Inst. of Inform. Theory and Autom.	M. L. Corradini	Univ. di Ancona
Michael. Sebek	Inst. of Inform. Theory and Autom.	T. Leo	Univ. di Ancona
J. Stecha	Inst. of Inform. Theory and Autom.	G. Orlando	Univ. di Ancona
2:30		2:30	
<i>Design of Fault-Tolerant LTI State-Space Systems</i>		<i>Control of Robot Manipulators Using CMAC Neural Networks</i>	
C. N. Hadjicostis	Massachusetts Inst. of Tech.	S. Commuri	CGN & Associates
G. C. Verghese	Massachusetts Inst. of Tech.	S. Jagannathan	Automated Analysis Corp.
		F. L. Lewis	Univ. of Texas at Arlington
3:00		3:00	
<i>An Integrated Framework for Input, Output and Control Structure Selection: Advanced Control Diagnostics</i>		<i>On the Development of a Quick Connect Disconnect Coupler for Rapidly Configured Modular Robots</i>	
N. Karcianas	City Univ.	P. S. Shiakolas	Univ. of Texas Arlington
J. Leventides	City Univ.	T. W. Sharpe	Univ. of Texas Arlington
E. Milonidis	City Univ.	T. J. Lawley	Univ. of Texas Arlington
3:30		3:30	
<i>System Zeros Analysis via SVD of the First Nonzero Markov Parameter and the Kalman Decomposition Theorem</i>		<i>Robot Control Using a Sliding Mode</i>	
Jerzy Tokarzewski	Military Univ. of Tech. Poland	M. Belhocine	Centre de Dev. des Tech. Avances
		M. Hamerlain	Centre de Dev. des Tech. Avances
		K. Bouyoucef	Centre de Dev. des Tech. Avances
4:00			
<i>Constrained Controllability of Dynamical Systems</i>			
Jerzy Klamka	Tech. Univ. Poland		

5th IEEE MED

Wednesday, July 23

		Chariot	12:00
WA1			<i>Emergency Control of Unstable Behavior of Nonlinear Systems Induced by Fault</i>
Nonlinear Systems			
Chair: J. S. Shamma	Univ. of Texas Austin	Mark A. Pinsky	Univ. of Nevada Reno
Chair: M. M. Polycarpou	Univ. of Cincinnati	Michael V. Basin	Univ. of Nevada Reno
9:00			
<i>Set-Valued State Observers for Nonlinear Systems</i>			
Jeff S. Shamma	Univ. of Texas Austin		
Kuang-Yang Tu	Univ. of Texas Austin		
9:30			
<i>State Observers for Nonlinear Systems With Smooth/Bounded Input</i>			
A. Germani	Univ. degli studi dell Aquila		
C. Manes	Univ. degli studi dell Aquila		
10:00			
<i>Parameter Identification of Nonlinear Systems With Known Structure</i>			
Alessandro Astolfi	Imperial College		
J. J. Milek	ETH Swiss Fed. Inst. of Tech.		
F. J. Kraus	ETH Swiss Fed. Inst. of Tech.		
10:30			
<i>Design and Analysis of Incipient Fault Diagnosis Schemes Using On-Line Approximators</i>			
Marios M. Polycarpou	Univ. of Cincinnati		
Michael A. Demetriou	Worcester Polyt. Inst.		
11:00			
<i>On Feedback Linearization Solution</i>			
M. Hou	Loughborough Univ.		
A. C. Pugh	Loughborough Univ.		
11:30			
<i>On Singular Phenomena in Certain Time-Optimal Feedback System Operating by Discontinuous Resistance</i>			
Wladyslaw Hejmo	Cracow Univ. of Tech.		

WA2		Apollo	11:30	
Applications			<i>Modeling and Simulation of a Blood Pump for Controller Development</i>	
Chair: N. Denis	Univ. of Massachusetts Amherst		Yih-Choung Yu	Univ. of Pittsburgh
Chair: C. Vaucoret	ENSICA/DFR/AS		James F. Antaki	Univ. of Pittsburgh
			J. Robert Boston	Univ. of Pittsburgh
			Marwan Simaan	Univ. of Pittsburgh
			Phil J. Miller	Baxter Healthcare
9:00			12:00	
<i>A Symbolic Sensor for an Antilock Brake System of a Commercial Aircraft</i>			<i>The Control and Structures Research Laboratory (CSRL): A Control-Oriented Test-Bed for Large Segmented Reflectors</i>	
B. Ewers	ENSICA/DFR/AS		Majdedin Mirmirani	California State Univ. Los Angeles
J. Bordeneuve-Guibe	ENSICA/DFR/AS		Helen R. Boussalis	California State Univ. Los Angeles
Corinne Langlois	Aerospatiale		Khosrow Rad	California State Univ. Los Angeles
9:30			Mohiuddin Ahmed	California State Univ. Los Angeles
<i>Multivariable Predictive Controller for a Test Stand of Air Conditioning</i>			Anastasios Chassiakos	California State Univ. Long Beach
Cyril Vaucoret	ENSICA/DFR/AS		Petros Ioannou	Univ. of Southern California
Joel Bordeneuve-Guibe	ENSICA/DFR/AS		Elias Kosmatopoulos	Univ. of Southern California
10:00				
<i>Hinf Control Design For an Adaptive Optics System</i>				
Nikolaos Denis	Univ. of Massachusetts Amherst			
Douglas. Looze	Univ. of Massachusetts Amherst			
Jim Huang	Alphatech			
David Castanon	Boston Univ.			
10:30				
<i>Optimal Fixture Design for Drilling in Elastically Deforming Plates</i>				
K. Wardak	Univ. of Maryland BC			
U. Tasch	Univ. of Maryland BC			
P. G. Charalambides	Univ. of Maryland BC			
11:00				
<i>Development of Mold Level Controller Using Sliding Mode Control in a Continuous Casting Processing</i>				
Seung Ryeol Yoo	Tech. Research Lab. POSCO			
Young Seub Kueon	Tech. Research Lab. POSCO			

Zeus		Lindos	
WA3		WA4	
Linear Systems II		Automotive Systems	
Chair: P. G. Voulgaris	Univ. of Illinois Urbana-Champaign	Chair: P. Ioannou	Univ. of Southern California
Chair: B. Kouvaritakis	Univ. of Oxford	Chair: R. Majjad	Univ. of Karlsruhe
9:00		9:00	
<i>I1-Optimal Control for Multirate Systems Under Full State Feedback</i>		<i>Macroscopic Traffic Flow Modeling of Automated Highway Systems</i>	
Johannes Aubrecht	Univ. of Illinois Urbana-Champaign	H. Raza	Univ. of Southern California
Petros G. Voulgaris	Univ. of Illinois Urbana-Champaign	Petros. Ioannou	Univ. of Southern California
9:30		9:30	
<i>Ellipsoidal Bounding in Stable Predictive Control</i>		<i>Robust Prevention of Limit Cycles for Robustly Decoupled Car Steering Dynamics</i>	
M. Cannon	Univ. of Oxford	Juergen Ackermann	DLR
B. Kouvaritakis	Univ. of Oxford	Tilman Buente	DLR
10:00		10:00	
<i>Constrained Stable Predictive Control: An I2-Optimal Approach</i>		<i>Modular Design for the Computation of Vehicle Dynamic Behavior</i>	
B. Kouvaritakis	Univ. of Oxford	R. Majjad	Univ. of Karlsruhe
J. A. Rossiter	Loughborough Univ.	U. Kiencke	Univ. of Karlsruhe
M. Cannon	Univ. of Oxford		
10:30		10:30	
<i>The Performance of Generalized Minimum Variance System Identification</i>		<i>Identification of Parameters for Complex Vehicle Models</i>	
Odell R. Reynolds	Air Force Inst. of Techn.	R. Majjad	Univ. of Karlsruhe
Meir Pachter	Air Force Inst. of Techn.	M. Hafner	Univ. of Karlsruhe
11:00		11:00	
<i>Weighted Hinf Mixed-Sensitivity Minimization for Stable Distributed Parameter Plants Under Sample-Data Control</i>		<i>Application Car Dynamics Model</i>	
Delano R. Carter	Arizona State Univ.	Said. Bentalba	Univ. de Picardie-Jules Verne
Armando A. Rodriguez	Arizona State Univ.	A. El Hajjaji	Univ. de Picardie-Jules Verne
		A. Rachid	Univ. de Picardie-Jules Verne
11:30		11:30	
<i>On Sample-Data Control Systems With Discontinuous Output</i>		<i>Sliding Mode Control of a Turbocharged Diesel Engine</i>	
Marian J. Blachuta	Silesian Tech. Univ.	S. Ouenou-Gamo	Univ. de Picardie Jules Verne
		A. Benchaib	Univ. de Picardie Jules Verne
		A. Rachid	Univ. de Picardie Jules Verne
		M. Ouladsine	Univ. de Picardie Jules Verne

Chariot		Apollo	
WP1		WP2	
Two-Dimensional Systems		Adaptive Control	
Chair: N. E. Mastorakis	Hellenic Naval Academy	Chair: I. Kanellakopoulos	Univ. of California Los Angeles
Chair: N. Denis	Univ. of Massachusetts Amherst	Chair: R. L. Kosut	SC Solutions
1:30		1:30	
<i>A New Method for Computing the Stability Margin for Two-Dimensional Systems</i>		<i>Adaptive Control of Discrete-Time Output-Feedback Nonlinear Systems</i>	
Nikos E. Mastorakis	Hellenic Naval Academy	Jiaxiang Zhao	Univ. of California Los Angeles
		Ioannis Kanellakopoulos	Univ. of California Los Angeles
2:00		2:00	
<i>New Stability Test for 2-D Systems</i>		<i>An Uncertainty Model Validation Approach to Adaptive Robust Linear Control</i>	
Nikos E. Mastorakis	Hellenic Naval Academy	Robert L. Kosut	SC Solutions
2:30		2:30	
<i>Reachability and Minimum Energy Control of Nonnegative 2-D Roesser Type Models</i>		<i>Application of a Multivariable Adaptive Controller With PID Structure to a Wastewater Treatment Plant With D-N Configuration</i>	
Tadeusz Kaczorek	Warsaw Univ. of Tech.	A. M. Macarulla	CEIT
3:00		J. Florez	CEIT
<i>Some Results on the Dynamics of 2D Positive Systems</i>		J. X. Ostolaza	CEIT
Ettore Fornasini	Univ. di Padova	E. Ayesa	CEIT
Maria Elena Valcher	Univ. di Padova		
		3:00	
		<i>Adaptive Variable Structure Control of Robot Manipulators With Exponentially Stable Trajectories</i>	
		Hongnian Yu	Liverpool John Moores Univ.

Zeus		Lindos	
WP3		WP4	
Linear Systems III		Digital Signal Processing II	
Chair: V. L. Syrmos	Univ. of Hawaii Manoa	Chair: C. N. Georgiades	Texas A & M Univ.
Chair: R. Draï	Ecole des Mines de Paris	Chair: A. Spanias	Arizona State Univ.
1:30		1:30	
<i>Normalized Coprime Factorizations for Discrete-Time Periodic Systems</i>		<i>An Application of the EM Algorithm to Sequence Estimation in the Presence of Tone Interference</i>	
Baohui Xie	Univ. of Hawaii Manoa	Quan G. Zhang	Texas A & M Univ.
Vassilis L. Syrmos	Univ. of Hawaii Manoa	Costas N. Georgiades	Texas A & M Univ.
2:00		2:00	
<i>The Tracking and Regulation Problem for a Class of Generalised Systems</i>		<i>A Non-Linear Filtering Algorithm for the Measurement of Rainfall Drop Size Distribution</i>	
Antonio Tornambe	Terza Univ. di Roma	Takis Kasparis	Univ. of Central Florida
		John Lane	Univ. of Central Florida
2:30		2:30	
<i>Dynamic Output Feedback Stabilization for a Class of Saturated Linear Systems</i>		<i>Invariant Line Matching of Consecutive Images</i>	
M. Klai	IGE	Djemaa Kachi	Univ. de Tech. de Compiegne
Y. Ait-Amirat	IGE	Xiao-Wei Tu	Univ. de Tech. de Compiegne
3:00			
<i>Stabilization Independent of Delay for Saturated Linear Systems</i>			
M. Klai	IGE		
Y. Ait-Amirat	IGE		
3:30			
<i>Design of L. Q. G. Dissipative Controllers Using Linear Matrix Inequalities</i>			
Remi Draï	Ecole des Mines de Paris		

MA1 Hybrid Systems

MA1-1

Automation Comparison Procedure for the Verification of Hybrid Systems

Wolf Kohn, Jeffrey B. Remmel, Anil Nerode

Abstract

This paper describes on-going research on a procedure for the verification of Hybrid System Controllers implemented with the Kohn-Nerode extraction procedure, [8, 10, 12], implemented by the Multiple Agent Hybrid Control Architecture (MAHCA) [11]. It is an automated static verification technique based on the construction of an Intersection Unification Automaton (IUA). Given a hybrid system controller generated by a MAHCA agent and a set of control specifications for its desired behavior, the proposed verification procedure builds an IUA constructed by an automata operation on two inference automata: the automaton encoding the specifications and the control automaton constructed by the inferencer of the agent [11]. The ultimate goal of our research is to develop a verification procedure to verify a MAHCA distributed implementation to a set of global requirement specifications. In this paper we discuss an essential step, namely a procedure to verify that the controller design generated by an agent in MAHCA meets the requirements established for that agent. The paper describes the functionality of the procedure and illustrates it with an example.

MA1 Hybrid Systems

MA1-2

A Hybrid System Approach to Feedback Control of a Nonholonomic Vehicle

J. Almeida, F. Lobo Pereira, J. Borges Sousa

Abstract

This paper addresses the design of a hybrid feedback control system enabling a car-like, rectangular vehicle to perform a tight L-shaped turn maneuver. This case constitutes an effort towards the definition of a general purpose methodology for hybrid feedback control synthesis. The design effort encompasses the synthesis of a set of modalities and mechanisms to detect relevant events enabling the overall motion coordination so that a global goal is attempted. Simulations of the implemented controller have shown a strong robustness with respect to modeling uncertainty and execution errors.

MA1 Hybrid Systems

MA1-3

Discrete Levels Control of Nonlinear Systems

Photis G. Skiadas, Nick T. Koussoulas

Abstract

We study an interesting issue arising in digital implementation and hybrid control systems frameworks, namely what are the basic characteristics of the behavior of a nonlinear dynamic system when it is driven by input that can assume only discrete levels. In particular, we focus on the controllability of nilpotent systems with and without drift, whose inputs take values in a finite discrete level set. In both cases, we prove that the constrained system and the corresponding unconstrained system have the same accessibility and controllability properties. An application of these results in motion planning for nonholonomic systems appears in a companion paper.

MA1 Hybrid Systems

MA1-4

A Framework for Hybrid Control Design and its Relations with a Class of Fuzzy Logic Control Systems

R. Fierro, F. L. Lewis, K. Liu

Abstract

This paper presents a Hybrid System Framework which considers simultaneously the lower-level control and decision-making issues. This reconfigurable framework can accommodate a wide range of situations, from aircraft control systems to mobile manipulators. A continuous-state plant is supervised by a discrete-event system which is based on a theory of linked finite state machines. The composite system is viewed as an iterative process where a task is carried out by changing the structure of the continuous-state plant. An application of this framework is illustrated through a mobile manipulator example. Finally, some connections between hybrid systems and a class of fuzzy logic control systems are established.

MA2 Stochastic Systems

MA2-1

Estimation of Hidden Markov Models for Partially Observed Risk Sensitive Control Problems

Bernard Frankpitt, John Baras

MA2 Stochastic Systems

MA2-2

Linear Gaussian Quadratic Regulation under Poisson Distributed Intermittent State Observations

M. Ades, P. E. Caines, R. P. Malhame

MA2 Stochastic Systems

MA2-3

Finite-Dimensionality of Information States in Optimal Control of Stochastic Systems

Charalambos D. Charalambous

Abstract

This paper is concerned with partially observed stochastic optimal control problems. The state of the system is described by a nonlinear controlled diffusion equation. The measurements are noisy linear combinations of the state, and the rate of change of the state of the system. Explicit representations for the information state are derived in terms of a finite-number of sufficient statistics. This allows application of Wonham's classical separation theorem.

MA2 Stochastic Systems

MA2-4

Tracking Changing Stochastic Models via Stochastic Binary Neural Networks

Anthony Burrell, Achilles Kogiantis, P. Papantoni-Kazakos

Abstract

We consider a sequential algorithm that detects changes from an acting stochastic model to any one of a number of alternatives. We adopt discrete approximations of the stochastic models and we propose the deployment of stochastic binary neural networks which are pretrained to produce the appropriate statistical measures associated with these models. The pretraining is implemented by a backpropogating supervised learning algorithm of stochastic approximation nature which converges almost surely under general conditions. The overall system performance is discussed and some numerical results are presented.

MA3 Modeling Estimation and Control of Infinite Dimensional Systems I

MA3-1

Spray Control

A. El Jai

MA3 Modeling Estimation and Control of Infinite Dimensional Systems I

MA3-2

Estimation and Control of Sample-Data Systems in Infinite Dimensions

Akira Ichikawa

Fault Accommodation of Output-Induced Actuator Failures for a Flexible Beam with Collocated Input and Output

Michael A. Demetriou, Marios M. Polycarpou

Abstract

In this note, we propose a nonlinear on-line parameter estimation method that utilizes neural network-based approximators for detecting changes due to actuator faults in a class of structured dynamical systems. The plant considered here is a cantilevered beam actuated via a pair of piezoceramic patches. We examine changes in the control input term, which provide a simple and practical model of actuator failures. Using Lyapunov redesign methods, a stable learning scheme is utilized in a control reconfiguration in order to accommodate the system's actuator failure. A numerical algorithm is provided for the implementation of the detection and accommodation scheme and simulation studies are used to illustrate the applicability of the theoretical results.

MA3 Modeling Estimation and Control of Infinite Dimensional Systems I

MA3-4

Sampled Weighted Attraction Control of Distributed Thermal Scan Welding

Charalambos C. Doumanidis

MA4 Digital Signal Processing I

MA4-1

Algorithms for Phase Acquisition for QAM Constellations

Costas N. Georgiades

Abstract

Because of their relatively good performance, large QAM constellations are being used in many current communication applications. One of the problems associated with the use of large QAM constellations is that of carrier acquisition, which for efficiency reasons must often be done without the use of preamble. The problem is further complicated for cross constellations, for which the high SNR corner points used by some simple carrier phase estimators are not available. In this paper we derive simple algorithms for carrier phase acquisition that can be used for both square and cross constellations, and compare their performance to that of the 4-th power estimator. The introduced algorithms convert the problem of carrier phase estimation into one of estimating the mode of an underlying distribution.

MA3 Modeling Estimation and Control of Infinite Dimensional Systems I

MA4-2

Maximum Likelihood Estimation of Scale

John A. Stuller

Abstract

This paper introduces the solution to the problem of maximum likelihood (ML) scale estimation. The result is obtained using coupled Karhunen-Loeve expansions, which were recently introduced in [1-3] to solve the problem of ML displacement (or time delay) estimation. The coupled Karhunen-Loeve expansions lead directly to intuitively reasonable signal processors associated with ML displacement and ML scale estimation. Simulations results that demonstrate the performance of ML scale estimation are included in this paper.

MA3 Modeling Estimation and Control of Infinite Dimensional Systems I

MA4-3

A Novel BPSK Demodulator Using the Expectation Maximization Algorithm

Takis Kasparis, Gregory Powel

Abstract

A novel coherent demodulator is proposed which utilizes the expectation-maximization (EM) algorithm for carrier phase recovery. The EM algorithm is feed-forward, and therefore produces no carrier phase error to be fed back to the down conversion process. The algorithm produces a maximum likelihood estimate of the modulating bit sequence, given the received in-phase and quadrature-phase data. Previously, the EM algorithm has been used to demodulate Binary Phase Shift Keying (BPSK) modulated signals, but assumed perfect symbol synchronization. This work combines the EM algorithm with a symbol timing estimation (TE) algorithm to produce a complete BPSK demodulator. The results of the TE algorithm are used to control a polyphase matched filter, which performs root-raised cosine matched filtering as well as symbol timing correction. Simulation results show that the proposed demodulator performs within 1 dB of theory, given constant carrier phase error and/or constant symbol timing error. The demodulation performs within 0.75 dB of theory given a carrier frequency offset of 1.5% of the symbol rate.

MA3 Modeling Estimation and Control of Infinite Dimensional Systems I

MA4-4

A New Phase Model for Sinusoidal Transform Coding of Speech Signals

Sassan Ahmadi, Andreas S. Spanias

Abstract

A new phase modeling algorithm for sinusoidal analysis/synthesis of speech is presented. Short-time sinusoidal phases are approximated using a combination of linear prediction, spectral sampling, delay compensation and phase correction techniques. The algorithm is different than phase compensation methods proposed for source-system LPC in that it has been optimized for sinusoidal representation of speech. Performance analysis on a large speech database indicates considerable improvement subjective quality of the reconstructed speech. The extra parameter used for representation of the sine wave phases require a small number of bits. The method can be applied to enhance phase matching in low-bit rate sinusoidal coders, where underlying sine wave amplitudes are extracted from an all-pole model.

MP1 Discrete Event Systems

MP1-1

Supervisory Control Using Computationally Efficient Linear Techniques: A Tutorial Introduction

John O. Moody, Panos J. Antsaklis

Abstract

This paper provides an overview of a computationally efficient method for synthesizing supervisory controllers for discrete event systems (DES). The DES plant and controller are described by Petri nets which provide a useful linear algebraic model for both control analysis and synthesis. It is shown how a set of linear constraints on the plant's behavior can be enforced, accounting for possibly uncontrollable or unobservable transitions in the plant net, using techniques from Petri net theory, integer programming, and linear systems. The paper is written as a tutorial introduction to the approach. Several results here have been reported elsewhere in the literature.

MP1 Discrete Event Systems

MP1-2

Dynamic Resource Allocation in Discrete Event Systems

Christos G. Panayiotou, Christos G. Cassandras

Abstract

In this paper we develop a controller for dynamic resource allocation in Discrete Event Systems (DES) operating in a stochastic environment. The controller's objective is to allocate a finite number of discrete resources to a set of users so as to achieve optimal systems performance. The derived controller uses concurrent estimation, a sample path constructability technique for DES, to obtain estimates of the system's performance under a set of hypothetical parameter settings using only information observed from the real system. Subsequently, these estimates are used by an on-line algorithm which reallocates the resources among the various users to achieve our objective. An application to a buffer allocation problem is included along with explicit numerical results illustrating the use of this dynamic allocation scheme.

MP1 Discrete Event Systems

MP1-3

Dynamic Neural Networks for Real-Time Manufacturing Cell Scheduling

George A. Rovithakis, Vassilis I. Gaganis, Stelios E. Perrakis, Manolis A. Christodoulou

Abstract

In this paper, a control aspect of the non-acyclic FMS scheduling problem is considered. Based on a dynamic neural network model derived herein, an adaptive, continuous time neural network controller is constructed. The actual dispatching times are determined from the continuous control input discretization. The controller is capable of driving system production to the required demand and guaranteeing system stability and boundedness of all signals in the closed loop system. Modeling errors and discretization effects are taken into account thus rendering the controller robust. A case demonstrates the efficiency of the proposed technique.

MP1 Discrete Event Systems

MP1-4

A State Reconstruction Algorithm for Parameter Dependent Discrete Event Dynamic Systems

Francesco Martinelli, Salvatore Nicosia, Paolo Valigi

Abstract

In this paper, the problem of state reconstruction for the class of parameter dependent discrete event systems that can be modeled by means of queuing networks is considered, and a novel solution is proposed, based on the use of data extracted from the observation of a real system. The algorithm allows to accurately reconstruct the state behavior of a queuing network, for values of the parameters of the system different from the nominal ones. The proposed approach has been applied to the on-line control problems for real systems, and a complete control procedure is proposed.

MP1 Discrete Event Systems

MP1-5

A Model for Two-stage Manufacturing Systems

Wai Ki Ching

Abstract

This paper studies a two-stage (two machines in tandem) manufacturing systems under hedging point production policy. The manufacturing system produces one type of product and its demand is modeled as a Poisson process. Each product has to go through the manufacturing process by a reliable machine in each stage. Preconditioned Conjugate Gradient (PCG) method is employed to solve the steady state probability distribution of systems. Preconditioner is constructed by taking circulant approximation of the generator matrix of the system. We prove that the preconditioned linear system has singular values clustered around one when the number of inventory levels tend to infinity. Hence conjugate gradient methods will converge very fast when apply to solving the preconditioned linear system. Numerical examples are given to verify our claim. The average running cost can be written in terms of this probability. By varying different possible values of hedging point h , the optimal value of h which minimizes the average running cost can be obtained. Extension to multiple parallel machines in each stage is also discussed.

MP2 Nonlinear and Stochastic Control: Theory and Application

MP2-1

Dynamic Vision and Estimation Theory on Spheres

Giorgio Picci

MP2 Nonlinear and Stochastic Control: Theory and Application

MP2-2

Generalized Wiener-Hopf Factorization of Discrete-Time All-Pass Functions

Gyorgy Michaletzky

MP2 Nonlinear and Stochastic Control: Theory and Application

MP2-3

Observers for Systems with Implicit Output

A. Matveev, X. Hu, R. Frezza

Abstract

In this paper we consider a system whose output is implicitly defined. The system is assumed to be Lyapunov stable but not asymptotically stable. The problem we consider is to construct a dynamical observer. This system is somehow similar to a linear time-varying system. However, the difference is that the C matrix varies with output here. As far as we know, even for linear time-varying systems, constructing an observer is far from trivial.

MP2 Nonlinear and Stochastic Control: Theory and Application

MP2-4

On the Covariance Extension Problem

Christopher I. Byrnes, Anders Lindquist

MP2 Nonlinear and Stochastic Control: Theory and Application

MP2-5

Cross-Ratio Dynamics and its Applications to Calibration Free Motion Estimation

Bijoy K. Ghosh

MP2 Nonlinear and Stochastic Control: Theory and Application

MP2-6

Control of the Planar Rotation in Human Head-Eye-Coordination

Magnus Egerstedt, Clyde F. Martin

Abstract

In this article, the problem of how to model and control the combined motion of the human head and eye is being investigated. Based on a simplified physical model and an assumption that the muscles can be modeled as damped springs with a second order linear dynamics, we derive models, for which we then can find control laws that both make the combined pupil-movement follow a given trajectory, and make the separate head eye trajectories three times continuously derivable. Our control also make the energy produced in the movement small, since we believe that to be a reasonable, physical control-criterion. We also investigate what role time delay plays when it comes to switching between active and inactive muscles.

MP3 Modeling Estimation and Control of Infinite Dimensional Systems II

MP3-1

Inverse Problems for Nonautonomous Nonlinear Distributed Parameter Systems

Azmy S. Ackleh, Simeon Reich

Abstract

We will consider inverse problems involving the identification of time dependent, nonlinear, distributed parameter systems. A general convergence result for parameter estimates obtained using Galerkin approximations is presented. The application of our theory to an example is discussed.

MP3 Modeling Estimation and Control of Infinite Dimensional Systems II

MP3-2

Minimax H-Infinity Control of Stable Distributed Systems

Kelly Black

MP3 Modeling Estimation and Control of Infinite Dimensional Systems II

MP3-3

Adaptive Identification of Distributed Parameter Systems

Yuri Orlov, Joseph Bentsman

Abstract

This work presents synthesis of adaptive identifiers for distributed parameter systems (DPS) described by partial differential equations (PDE's) of parabolic, elliptic, and hyperbolic type. The novel feature of the identification algorithms presented is the lack of a need for computing second spatial derivatives for the cases of several unknown parameters. This feature makes the algorithms much more applicable in the presence of measurement nonlinearities. The fundamental concept of identifiability is studied. Adjustable parameters in the adaptive identifiers proposed are shown to admit simultaneous convergence to their nominal space-varying values when an appropriate input signal is used. The class of sufficiently rich input signals referred as generators of persistent excitation is defined. This class guarantees the existence of a unique zero steady state for the parameter errors, thereby yielding unknown plant parameters.

MP3 Modeling Estimation and Control of Infinite Dimensional Systems II

MP3-4

Parameter Estimation in a Nonlinear Structured Tree Population Model With Self Shading Effects

Azmy S. Ackleh

Abstract

We discuss a least square method for identifying the growth function in a nonlinear hyperbolic initial-boundary value problem that describes the dynamics of tree population with self shading effects. Furthermore, we present numerical results of estimating this parameter from computationally generated data.

MP4 Control of Automotive Engines and Drivelines

MP4-1

Automated Design of an Air/Fuel Controller for an SI Engine Considering the Three-way Catalytic Converter in the Hinf approach

C. A. Roduner, C. H. Onder, H. P. Geering

Abstract

The correct operation of the emissions reduction system of an SI engine depends on the capability of the three-way catalyst (TWC) to store and release oxygen. Either one or the other is lost if the oxygen storage of the TWC is completely full or completely empty. In order to optimally handle upstream air-to-fuel ratio (λ) excursions in either direction (lean or rich), the stored oxygen mass should be kept near the middle of the current oxygen storage capacity. An Hinf controller is developed which takes into account the dynamic behavior of the TWC. The main design goal is to compensate the disturbance impact on the relative oxygen storage level by first measuring the upstream air-to-fuel ratio only. For this purpose the TWC is regarded as a limited integrator. The dynamics of the fuel-path subsystem of the engine (between fuel injection and measured upstream air-to-fuel ratio) is modeled by lowpass element and a time delay connected in series. Since the measurements on an engine test bench illustrate the performance of the control system.

MP4 Control of Automotive Engines and Drivelines

MP4-2

Feedback Linearization of a Multi-Input SI-Engine System for Idle Speed Control

R. Pfiffner, L. Guzzella

Abstract

The idle speed control problem is a classical example of an automotive control application. The set-up corresponds to a disturbance rejection problem where the main plant output (engine speed) has to be maintained at a (low) constant value despite the torque disturbances acting on the engine crank-shaft (servo-steering pump, air-conditioning compressor etc.). The relevance (comfort, fuel consumption etc.) and the technical challenges (nonlinear plant with large time delays and uncertainties) of this control problem have led to many different control strategies. PID, LQ, Hinf, fuzzy control, adaptive control, sliding mode and neural networks are some of the frameworks used to tackle this problem. Feedback linearization was also investigated in some papers, but the engine's induction power stroke delay was neglected. Unfortunately, this effect, that depends in addition on the engine speed, is often the limiting factor for the controller design. For this reason in the here presented work, this delay is approximated with a cascade of two first order low pass elements, which have engine-speed dependent time constants. The resulting nonlinear fourth order plant with two inputs (air bypass valve and spark advantage) is not affine in both inputs. Nevertheless, by introducing additional static compensations the plant is shown to be exactly feedback linearizable. The linearized plant permits the application of well-known linear control design methods. In this paper the different bandwidths of the two inputs are used in an Hinf design to guarantee an optimal engine operation both under transient and steady-state conditions.

MP4 Control of Automotive Engines and Drivelines

MP4-3

Influence of Manifold Pressure Pulsation to Mean Value Models in Air-to-Fuel Ratio Control

M. Scherer, C. Arndt, O. Löffeld

MP4 Control of Automotive Engines and Drivelines

MP4-4

Modelling Internal Combustion Engines via Identification Techniques

R. Scattolini, G. De Nicolao, M. Cittadini, C. Rossi, C. Siviero

Abstract

This paper deals with the identification of NARX (Nonlinear Autoregressive eXogeneous) models for describing the pressure inside the intake manifold and the crankshaft speed of Internal Combustion car engines. The proposed method is based on stepwise regression and has been applied to real data collected on a 1200 cm³ commercial engine. A number of experimental results witness the applicability of the approach.

MP4 Control of Automotive Engines and Drivelines

MP4-5

Identification of Emission Models in a Spark Ignition Engine for Control Applications

I. Arsie, C. Pianese, G. Rizzo

MP4 Control of Automotive Engines and Drivelines

MP4-6

Advanced System Design and Control Aspects in a Fuel-Optimal Hybrid Vehicle

E. Shafai, P. Dietrich, C. Wittmer, S. Ginsburg

Abstract

Electric vehicles today clearly represent the only solution fulfilling the zero emission vehicles (ZEV) standard. However, they still are not an equivalent alternative to the gasoline driven cars due to the well known problems of today's batteries. The concept of a parallel hybrid drive line can be an optimal combination of both principles of propulsion in that the gasoline engine guarantees for a wide range of operation, while the electric propulsion can be used within the restricted zero emission zones. The parallel hybrid solution described here has been realized in the "Hybrid III" research and development project at the Swiss Federal Institute of Technology (ETH), Zurich, Switzerland. The drive line consists of a gasoline engine, an electric asynchronous motor/generator, a flywheel, and a wide range continuously variable transmission. It is shown how these components cooperate in a fuel-optimal way. This drive line is now about to be integrated in a vehicle for real road testing. This paper describes the experimental results on a dynamic test bench verifying its operation under realistic traffic conditions.

TA1 Intelligent Systems

TA1-1

A State Configured Sensor Based Control Architecture for an Autonomous Underwater Vehicle

G. A. Demetriou, K. H. Valavanis

Abstract

A new embedded control system hardware and software control architecture suitable for an AUV is presented. The proposed scheme is based on the shared memory principle and consists of three components, a supervisory controller, a functional and a hardware/execution component. Off-the-shelf technology has been used to build and implement the described AUV control architecture. Key features of the proposed architecture include: autonomy, learning, recovery, multiple goals in a single mission, use of multiple sensors for data collection. This embedded architecture is modular, reconfigurable, expandable and cost-effective.

TA1 Intelligent Systems

TA1-2

The Use of Fuzzy Cognitive Maps in Modeling Systems

Chrysostomos D. Stylios, Voula C. Georgopoulos, Peter P. Groumpos

Abstract

This paper investigates a new theory, Fuzzy cognitive Map (FCM) Theory, and its implementations in modeling systems. First the description and the methodology that this theory suggests is examined and then the application of FCM in a process control problem is described. The presentation indicates how powerful FCMs are and some interesting points for further research are included. In the recent years, a wide discussion has started about the autonomy and intelligence of systems, so the application of FCM in the field of control and systems may contribute in the development of more intelligent and autonomous control systems.

TA1 Intelligent Systems

TA1-3

Fuzzy Linear Programming and Simulated Annealing

Rita Almeida Ribeiro, Fernando Moura Pires

Abstract

This paper shows how the simulated annealing (SA) algorithm provides a simple tool for solving fuzzy optimization problems. Often, the issue is not so much how to fuzzify or remove the conceptual imprecision, but which tools enable simple solutions for these intrinsically uncertain problems. A well-known linear programming example is used to discuss the suitability of the SA algorithm for solving fuzzy optimization problems.

TA1 Intelligent Systems

TA1-4

State Estimation in Presence of Disturbance Using Neural Networks

B. Gaddouna Ouladsine, G. Bloch

Abstract

A state reconstruction method of non-linear systems is proposed. It concerns the systems which can be decomposed into linear and non-linear parts and requires the implementation of two observers. The first one is used for determining approximately the target of a neural network providing the estimation of the nonlinearity. This one can be the consequence of modeling errors of the system parameters. The second one allows to reconstruct the state of the nonlinear system.

On-Line Neural Network Algorithm for the Constrained Motion Planning of Redundant Manipulators

A. Ramdane-Cherif, D. Y. Meddah, V. Perdereau, M. Drouin

Abstract

In this paper, we propose an iterative method using a neural network to solve the inverse kinematic problem for redundant manipulators in presence of motion constraints such as joint limits or obstacles. A constrained optimization scheme with penalty functions based on neural network is formulated. The neural network is adapted in the direction of decreasing a Lyapunov function to move the end-effector to the desired position while avoiding a collision with respectively a workspace object and a contact environment surface. This approach offers substantially better accuracy and avoids the computation of the inverse or pseudoinverse Jacobian matrix. The application of this scheme to a 3 degrees of freedom redundant manipulator is demonstrated through simulation results.

On the Selection of Nodes in Linear-in-the-Weight Neural Networks

Elias B. Kosmatopoulos, Nikitas J. Dimopoulos

Abstract

Linear-in-the-weights neural networks are known to possess certain advantages over classical multilayer neural networks. In the past, there have been many learning algorithms proposed for training linear-in-the-weights neural networks [12, 8, 9, 10]; among the nice properties of those algorithms are their stability, convergence and robustness properties and, most important, their convergence to the -unique - global minimum. However, all these algorithms deal with the case where the neural network has fixed regressor terms (nodes). The problem of selecting the regressor terms in neural networks is still an open and unsolved problem. In this paper, we propose algorithms for selecting the regressor terms in linear-in-the-weight neural networks. These algorithms are accompanied by appropriate learning algorithms for adjusting the weights of the neural network. By analyzing an appropriate error functional, we investigate the convergence properties of the proposed algorithms; moreover, we investigate the optimality of these algorithms and we construct conditions - regarding the nature of the regressor terms - under which the proposed algorithms are optimal.

A Simplex Trained Neural Network-Based Architecture for Sensor Fusion and Tracking of Target Maneuvers

Yee Chin Wong, Malur K. Sundareshan

Abstract

One of the major applications for which neural network-based methods are being successfully employed is in the design of intelligent integrated processing architectures that efficiently implement sensor fusion operations. In this paper we shall present novel scheme for developing fused decisions for surveillance and tracking in typical multi-sensor environments characterized by the disparity in the data streams arriving from various sensors. This scheme employs an integration of a multilayer neural network trained with features extracted from this multi-sensor data and a Kalman filter in order to permit reliable tracking of maneuvering targets, and provides an intelligent way of implementing an overall nonlinear tracking filter without any attendant increases in computational complexity. A particular focus is given to optimizing the neural network architecture and the learning strategy which are particularly critical to develop the capabilities required for tracking of target maneuvers. Towards these goals, a network growing scheme and a simplex algorithm that seeks the global minimum of the training error are presented. To provide validation of these methods, results of several tracking experiments involving targets executing complex maneuvers in noisy and clutter environments are presented.

TA2 Robust Systems I

TA2-1

The Finite Inclusions Theorem: A Tool for Robust Design

Theodore E. Djaferis

Abstract

Methods for robust controller design, are an invaluable tool in the hands of the control engineer. Several methodologies have been developed over the years and have been applied for the solution of specific robust design problems. One of these methods, is based on the Finite Inclusions Theorem (FIT) and exploits properties of polynomials. This has led to the development of FIT-based algorithms for robust stabilization, robust asymptotic tracking and robust noise attenuation design. In this paper, we consider SISO systems with parameter uncertainty and show how FIT can be used to develop algorithms for robust phase margin design.

TA2 Robust Systems

TA2-2

Every Mode Robust Stabilization of Jump Linear Systems via LMIs

M. Ait Rami

Abstract

This paper considers the mode-dependent state-feedback control problem of linear systems subject to random Markovian jumps in parameter values. For this kind of systems, the mean-square stability does not ensure the stability of every mode in the deterministic sense. We provide stabilizing solution in both senses. The proposed approach differs from the modified jump regulator approach and has several advantages. The proposed conditions are only sufficient, but less conservative. We can treat uncertainties that can affect modes or the transition probability matrix. The problem is formulated as a convex constraint (LMIs) one.

TA2 Robust Systems

TA2-3

Robust Diagonal Stabilization and Finite Precision Problem: An LMI Approach

Stephane Dussy

Abstract

Realization of digital filters or implementation of controllers in a digital computer may lead to unexpected instabilities resulting from the finite precision effects. Stability is usually ensured for an idealized discrete-time realization of the system. Nevertheless, as soon as A/D and D/A conversions get involved, the quantization of the state of the system, due to adder overflow, magnitude truncation, finite wordlength format, may introduce severe nonlinearities responsible for overflow oscillations, limit cycles or even chaotic behavior, even under zero input. This paper considers a parameter-dependent, discrete-time system in the companion form. We derive LMI conditions ensuring stability for the uncertain system in spite of the finite precision effect. We also seek an LMI formulation for the synthesis of a static output-feedback controller that guarantees robust stability for the finite precision problem.

TA2 Robust Systems

TA2-4

Robust Quasi NID Aircraft 3D Flight Control Under Sensor Noise

Marian J. Blachuta , Valery D. Yurkevich, Konrad Wojciechowski

Abstract

In the paper the design of an aircraft motion controller based on the Dynamic Contraction Method is presented. The control task is formulated as a tracking problem for Euler angles, where the desired decoupled output transients are accomplished under assumption of high-level, high-frequency sensor noise and incomplete information about varying parameters of the system and external disturbances. The resulting controller has a simple form of a combination of a low-order linear dynamical system and a matrix whose entries depend nonlinearly on certain measurable flight variables.

TA2 Robust Systems

TA2-5

Modeling and mu-Synthesis Robust Control of Two-Link Flexible Manipulators

Mansour Karkoub, Kumar Tamma

Abstract

Two-link robot manipulators are commonly used in industrial sectors such as manufacturing. Some manipulators are often bulky and their power consumption is relatively high. Others, such as the arm on the space shuttle, are driven slow to prevent the onset of flexible oscillations. The efficiency of these manipulators can be improved by reducing the weight of some of these arms and/or increasing the speed of others. These modifications complicate the dynamic behavior of the system due to the possible onset of low frequency oscillations. This paper addresses the issue of modeling and end-point robust control of two-link flexible manipulators using the mu-synthesis technique. The Timoshenko beam theory along with the assumed modes method are used to derive reference equations of motion for the flexible manipulator. Discrepancies between the control design model and the actual dynamics of the manipulator are attributed to neglect non-linearities such as cross-coupling which should be included in the controller design. A linear estimation of these errors will be identified and used in the control design to compensate for the unmodelled dynamics of the flexible arm and parameter uncertainties. The mu-synthesis control design techniques are then employed to synthesize controllers for the two-link flexible robot manipulator.

TA2 Robust Systems

TA2-6

Exponentially-Weighted Iterative Solutions for Worst-Case Parameter Estimation

Ali H. Sayed, Andrea Garulli, V. Nascimento, S. Chandrasekaran

Abstract

This paper proposes an iterative scheme for worst-case parameter estimation in the presence of bounded model uncertainties. The algorithm distinguishes itself from other estimation schemes, such as errors-in-variables and other Hinf methods, in that it leads to less conservative designs since it explicitly incorporates an a-priori bound on the size of the uncertainties. It also employs an exponential weighting scheme where data in the remote past are given less weight than the most recent measurements. This feature is especially useful in tracking problems where recent observations carry more information about the current value of the unknown parameter. Simulation results are included to demonstrate the performance of the recursive scheme.

TA2 Robust Systems

TA2-7

Some Issues on Robust Control for Nonlinear Systems

Michael Athans, Alan Chao

TA3 Modeling Estimation and Control of Infinite Dimensional Systems III

TA3-1

Optimal Location of Actuators for an Active Noise Control Problem

Fariba Fahroo

Abstract

In this paper, we investigate the problem of finding the optimal location of controllers to achieve reduction of the noise field in an acoustic cavity. We first formulate a linear quadratic tracking problem in a Hilbert space, and then consider the problem of optimization of an appropriate performance criterion with respect to the location of the controls. Numerical examples will be presented to illustrate our theoretical results.

TA3 Modeling Estimation and Control of Infinite Dimensional Systems III

TA3-2

Minimax Hinf Control of Stable Distributed Systems

Olof J. Staffans

Abstract

We study the distributed suboptimal full information Hinf problem for a stable well-posed linear system with control u , disturbance w , state x and output y . In our setting the transfer functions need not be rational or meromorphic; they are just plain Hinf without extra smoothness. The problem is to find all suboptimal compensators, i.e. compensators that make the norm of the closed loop input/output map from w to y less than a prescribed constant. We use a game theory approach to this problem and regard it as a two player non-zero sum game.

TA3 Modeling Estimation and Control of Infinite Dimensional Systems III

TA3-3

Conditional Moment Generating Functions for Integrals and Stochastic Integrals: Maximum-Likelihood Estimation

Charalambos D. Charalambous

Abstract

In this paper we present two methods for computing filtered estimates for moments of integrals and stochastic integrals of continuous-time nonlinear systems. The first method utilizes recursive stochastic partial differential equations. The second method utilizes conditional moment generating functions. For the case of Gaussian systems the recursive computations involve integrations with respect to Gaussian densities, while the moment generating functions involve differentiations of parameter dependent ordinary stochastic differential equations. The second method is applied in the expectation optimization algorithm.

TA3 Modeling Estimation and Control of Infinite Dimensional Systems III

TA3-4

Ergodic Boundary Control of Semilinear Systems

T. E. Duncan

TA4 Mobile Robots

TA4-1

A Robust-Adaptive Locomotion Controller For 9-Link Biped with Rapidly Varying Unknown Parameters

S. G. Tzefestas, A. E. Krikochoritis, C. S. Tzefestas

Abstract

The control and the study of motion of a biped robot has always been a challenging problem. The mechanical complexity of biped robots, the existence of an unpowered degree of freedom and the peculiarity of their motion due to the repeatability of movements and a permanent change of situations during one step, synthesize a complex problem. At the same time, undesired collisions with its environment, transport of unknown loads, or simplification of some dynamic characteristics, cause uncertainty (structured or not) which makes worse the control problem since an accurate model of the biped robot is not available. In this paper a nine link planar biped model is studied. It is a biped robot that includes not only the main links: legs, thighs and trunk, but also a two segments foot. For this biped robot, the kinematics and dynamic equations which describe completely the locomotion of the robot during the different phases of walking, are defined. Furthermore, a continuous walking pattern on a flat terrain is designed and the corresponding desired trajectories of the robot joints are calculated. Then, a nonlinear robust control technique is adopted, based on the fact that the control which has to ensure the stability of the biped robot must take into account the nonlinear dynamics of the system. This requires the knowledge of an accurate model of the biped robot, a condition that is never fulfilled because of the existence of disturbances and modelling inaccuracies such as parametric uncertainty and unmodeled dynamics. Thus, for the case there is not available a priori information about the unknown parameters, the parametric uncertainty has to be gradually reduced on-line by an adaptation or estimation mechanism. Here, rapidly time-varying unknown parameters are assumed, and a kind of robust-adaptive controller is designed which achieves robustness, while at the same time ensures that all signals in the closed-loop robot system are bounded the tracking error is of the order of parameter variations. Extensive simulation experiments showed the effectiveness of the proposed robust-adaptive control scheme.

TA4 Mobile Robots

TA4-2

An Assessment of Fuzzy Logic for Collision Avoidance in a Multiple Autonomous Mobile Robot System

Chris G. Dodds, Albert Zomaya

Abstract

A fuzzy logic approach for collision avoidance in a multiple autonomous mobile robot environment is proposed. Up to four robots are given starting points and destinations they must reach within a hypothetical indoor environment. The fuzzy logic method enables the robots to reach their intended destinations while avoiding stationary and mobile obstacles alike.

TA4 Mobile Robots

TA4-3

Steering a Robotic Snake

K. Sarrigeorgides, K. J. Kyriakopoulos

Abstract

In this paper we develop a methodology for steering on the plane the wheeled "snake" robot designed by Migadis and Kyriakopoulos. This mechanical system is subject to nonholonomic constraints. The kinematic model of the mobile robot is derived taking into consideration these constraints. The nonholonomic motion planning is solved by converting the multiple input system to a multiple-chain, single generator chained form via state feedback and a coordinate transformation. Simulation results are provided for a test case.

TA4 Mobile Robots

TA4-4

Motion Planning for Drift-Free Nonholonomic Systems Under a Discrete Levels Control Constraint

Photis G. Skiadas, Nick T. Koussoulas

Abstract

The motion planning problem for nonholonomic systems without drift is solved under the constraint that the control inputs can take values in a set that contains a finite number of allowable levels. If the system to be steered is also nilpotent or nilpotentizable, the steering can be exact. The results are applied in the steering of a simple system.

TA4 Mobile Robots

TA4-5

Dynamic Modelling of a Tricycle Mobile Robot

Andre Kamga

Abstract

A control law is derived for path tracking of a tricycle mobile robot after its dynamics modelling. The vehicle has a front steering and driving wheel and two free rear wheels with a common rotation axis. Thanks to poles placement, a controller in the form of a linear feedback of the errors (position, orientation, lateral speed, and angular speed) formally proves why such a system can be stabilized about a trajectory by using these above errors feedback to determine the command to the steering angle. Several simulation's results of the controller are presented.

TA4 Mobile Robots

TA4-6

A Navigation System With Self-Localization Capabilities for an Autonomous Mobile Robot

Alain Betourne, Alessandro Fefe, Salvatore Nicosia, Paolo Valigi

Abstract

In this paper a navigation system for an autonomous mobile robot is presented. The system is based on the joint use of an odometry, encoder based sensory system, of a vision system, and of an ultrasonic captor sensory system. A flexible hierarchical data structure is used to model complex, partially known, indoor environments, thus allowing the navigation system to drive the robot in these environments, and to perform periodic corrections of the robot position, by means of the vision system. The proposed approach for image processing is based on the use of the Hough transform. The paper describes the overall navigation system, giving details on the environment modeling approach, and on the image processing scheme. Experimental tests have been performed, showing the good accuracy achieved by the proposed position estimation scheme.

TA4 Mobile Robots

TA4-7

Path following with security margin: A new control algorithm for wheeled Robots

T. Hamel, P. Soueres, D. Meizel

Abstract

This paper addresses the problem of determining a feedback control law, robust with respect to localization errors, allowing a mobile robot to follow a prescribed path. The model we consider is a dynamic extension of the usual kinematic model of a car, in the sense that we defined the path curvature as a new state variable. The control variables are respectively the linear velocity and the derivative of the curvature. By defining a sliding manifold we determine a stabilizing controller for the nominal system i.e. when the exact configuration is supposed to be known. Then, using Lyapunov analysis, we prove that the system remains stable when the estimated values are used for feedback instead of the exact ones, and we characterize the robustness with respect to localization and curvature estimation errors. The result is expressed by determining a bounded attractive domain where the vehicle's configuration could possibly lie when the closed-loop control is performed with the estimated state values. This domain allows to compute easily a security margin for obstacle avoidance during the path-following phase. Experimental results are presented at the end of the paper.

TP1 Max-Algebra

TP1-1

Linear Projectors in the Max-Plus Algebra

G. Cohen, S. Gaubert, J.-P. Quadrat

Abstract

For operators between finite-dimensional free moduloids, images are defined in the standard way whereas the notion of kernel is replaced by the equivalence relation between elements with the same image. Given a moduloid X , any x in X , and two operators B ranging in X , and C with domain X , one raises the question of existence and uniqueness of an element in the equivalence class of x modulo the kernel of C and which in addition belongs to the image of B . Such an element is then called the projection of x onto the image of B parallel to the kernel of C . In a previous paper, this question has been solved for residuated (possibly nonlinear) operators. When a pair (B, C) satisfies the existence and uniqueness conditions, the image of B and the kernel of C are in direct sum or are transverse. In the present paper, we revisit this problem in the case of linear operators. We give a simpler characterization of transversality and an explicit formula for the projector. Unlike in vector spaces, for a given B , a transverse C need not exist, or, otherwise stated, the image of B is not always that of a linear projector. Indeed, the operators B for which this holds true are exactly those for which a generalized inverse exists. A computational algebraic test is given in order to check this property.

TP1 Max-Algebra

TP1-2

Equivalence Classes of Rank-3 Matrices in the Max-Algebra

Jean-Michel Prou, Edouard Wagneur

TP1 Max-Algebra

TP1-3

Control Synthesis Approaches Using the State Equations and the ARMA Model in Timed Event Graphs

Philippe Declerck

Abstract

An important aim is to make control synthesis of processes modelled by timed event graphs. Using the state equations, we solve the optimal tracking problem for any past evolution of the system. However, the model is only a picture of the reality and modelling errors and faults generate misestimation of the state vector. In the case of an unknown state vector, we propose to compensate this information loss by the use of "ARMA" model in control field.

TP1 Max-Algebra

TP1-4

Dynamic Control of Kanban System Over Dioid Algebra

B. Cottenceau, L. Hardouin, J.-L. Boimond

Abstract

An objective of the just in time (JIT) manufacturing is to reduce work in process (WIP) inventory and to satisfy the customers demand. The most celebrated component is the so called Kanban method that we study in the dioid algebra setting. By considering the model of a Kanban cell we purpose dynamic controls of such systems. The first proposed control law allows to both decrease the WIP of a classical Kanban cell and to keep its output behavior. The obtained result is based on the residuation theory. The analytical expression of this control law shows that the customers demand will be known over a temporal horizon. The second approach yields the greater control law in order to reduce the WIP and to keep the same stock evolution in the output buffer of a classical Kanban cell. It is shown that the optimal control obtained does not need to have the future behavior of the customers demand. Finally the proposed control laws are extended to manufacturing systems with multiple Kanban cells.

TP1 Max-Algebra

TP1-5

Reachability and Observability of Linear Systems Over Max-Plus

M. J. Gazarik, E. W. Kamen

Abstract

This paper discusses the properties of reachability and observability for linear systems over the max-plus algebra. Working in the event-domain, the concept of asticity is used to develop conditions for weak reachability and weak observability. In the reachability problem, residuation is used to determine if a state is reachable and to generate the required control sequence to reach it. In the observability problem, residuation is used to estimate the state. As in the continuous-variable case, a duality also exists between the properties. Finally, an adjoint system is generated from the residual calculation in the reachability case and utilized to generate a solution to the just-in-time (JIT) scheduling problem.

TP1 Max-Algebra

TP1-6

Controllability in the Max-Algebra

Jean-Michel Prou, Edouard Wagneur

Abstract

We are interested here in the reachability problem for DEDS in the max-algebra. We show that this problem leads to an eigenvector problem in the min algebra. More precisely, we show that given a max-linear system, then, for every natural number $k \geq 1$ there is a matrix Σ_k , whose eigenspace associated with the eigenvalue 1 (the multiplicative identity, which coincides here with the real number 0 in the min algebra contains all the states which are reachable in k steps. Although not dealt with in this paper, a similar result also holds by duality on the observability side.

TP1 Max-Algebra

TP1-7

Nonexpansive Maps and Option Pricing Theory

V. Kolokoltsov

Abstract

The famous Black-Sholes (BS) and Cox-Ross-Rubinstein (CRR) formulas are basic results in the modern theory of option pricing in financial mathematics. They are usually deduced by means of stochastic analysis; various generalizations of those formulas were proposed using more sophisticated stochastic models for common stocks pricing evolution. In this report, we argue that classical BS and CRR formulas can be actually obtained as a part of the theory of nonexpansive maps, which contribute now one of the popular object of investigation in $(\max, +)$ algebra and its applications to Discrete Event Systems. This framework leads to another type of generalizations of BS and CRR formulas characterized generally by more rough assumptions on common stocks. evolution, which are therefore easier to verify. On the other hand, this approach is more elementary: it leads to BS and CRR formulas without the use of either martingales or stochastic equations.

TP2 Robust Systems II

TP2-1

Robust Stability Analysis of GPC: An Application to Dead-Beat and Mean-Level Predictive Controllers

Roberto Hernandez-Berlinches

Most stability results in model predictive control are based on the assumption that the model describes the real plant perfectly. In real systems the model is always different to the process and a robust stability analysis is needed. In this paper it is shown how the Extreme Point Results theory can be used to analyze the robust stability of predictive controllers in a natural way with low computational cost.

TP2 Robust Systems II

TP2-2

Robust Stability of Non-Linear Time-Varying Systems

Ezra Zeheb

Abstract

Systems with time-varying non-linearity confined to a given sector (Lure type) and a linear part with uncertainty formulated by an interval transfer function, are considered. Sufficient conditions satisfying the Popov criterion for stability, which are computationally tractable, are derived. The problem of checking the Popov criterion for an infinite set of systems, is reduced to that of checking the Popov criterion for a finite number of fixed coefficient systems, each in a prescribed frequency interval.

TP2 Robust Systems II

TP2-3

Constrained Stabilization of a Dynamic System: A Case Study

F. Blanchini, S. Cotterli, G. Koruza , S. Miani, R. Siagri, L. Tubaro

Abstract

In this work we consider the problem of determining and implementing a state-feedback stabilizing controller law for a laboratory two-tank dynamic system in the presence of state and control constraints. We do this by exploiting the properties of the polyhedral Lyapunov functions, i.e. Lyapunov functions whose level surfaces are polyhedra, in view of their capability of providing an arbitrarily good approximation of the maximal set of attraction, which is the largest set of initial states which can be brought to the origin with a guaranteed convergence speed. We will first recall the basic theoretical background needed for the scope and then we will report and analyze the results of the practical implementation on a two-tank laboratory system of a linear variable-structure and a quantized control law proposed in literature. Finally an heuristic procedure for the determination of a static linear gain will be presented.

TP2 Robust Systems II

TP2-4

Robust and Reliable Hinf Output Feedback Control for Linear Systems With Parameter Uncertainty and Actuator Failure

Chang-Jun Seo, Byung Kook Kim

Abstract

The robust and reliable Hinf output feedback controller design problem is investigated for uncertain linear systems with actuator failures within a prespecified subset of actuators. The uncertainty considered here is time-varying norm-bounded parameter uncertainty in the state matrix. The output of a faulty actuator is assumed to be any arbitrary energy-bounded signal. An observer-based output feedback controller design is presented which stabilizes the plant and guarantees an Hinf-norm bound on attenuation of augmented disturbances, for all admissible uncertainties as well as actuator failures. The construction of the observer-based output feedback control law requires the positive-definite solutions of two algebraic Riccati equations. The result can be regarded as an extension of existing results on robust Hinf control and reliable Hinf control of uncertain linear systems.

TP2 Robust Systems II

TP2-5

Quadratic Stabilizability of Uncertain Continuous-Time Systems Under State and Control Constraints in the Presence of Disturbances

H. X. de Araujo, I. Queinnec, S. Tarbouriech

Abstract

The problem of finding a linear stabilizing state-feedback control for uncertain continuous-time linear systems with state and control constraints is addressed. Both convex-bounded parametric uncertainties and adaptive bounded disturbances are considered. Based on the theory of ellipsoidal positively invariant sets, a programming approach is proposed to solve the control design problem.

TP2 Robust Systems II

TP2-6

Delay-dependent Robust Stability Tests and Decay Estimates for Systems With Input Delays

Kostas Hrissagis, Olga I. Kosmidou

Abstract

The robust asymptotic stabilization of uncertain systems with delays in the manipulated variables is considered in this paper. Sufficient conditions are derived that guarantee closed-loop stability under state-feedback control in the presence of nonlinear and/or time-varying perturbations. The stability conditions are given in terms of scalar inequalities and do not require the solution of Lyapunov equations. The approach makes use of the matrix measure to yield robust-stability conditions. The problem of constrained control is also discussed, and alternative stability conditions for some case of saturation nonlinearities are presented. Estimates of the stability degree and the rate of decay of the solutions are also obtained. Finally, an example illustrates the results.

TP3 Linear Systems I

TP3-1

Transfer Function Equivalence of Feedback/Feedforward Compensators

Vladimir Kucera

Abstract

Equivalence of several feedback and/or feedforward compensation schemes in linear systems is investigated. The classes of compensators that are realizable using static or dynamic state feedback are characterized. Stability of the compensated system is studied. Applications to model matching are included.

TP3 Linear Systems I

TP3-2

Numerical Operations Among Rational Matrices: Standard Techniques and Interpolation

P. Husek, M. Sebek, J. Stecha

Abstract

Numerical operations on and among rational matrices are traditionally handled by direct manipulation with their scalar entries. A new and sometimes numerically attractive alternative is proposed here that is based on interpolation. The procedure begins with evaluation of the rational matrices in several complex points. Then all the required operations are performed consecutively on constant matrices corresponding to each particular point. Finally, the resulting rational matrix is recovered from the particular constant solutions via interpolation. It may be computed either in polynomial matrix of rational functions. The operations considered include addition, multiplication and computation of polynomial matrix fraction form. The standard and the two interpolation methods are compared by experiments.

TP3 Linear Systems I

TP3-3

Design Fault-Tolerant of LTI State-Space Systems

C. N. Hadjicostis, G. C. Verghese

Abstract

The design of linear time-invariant (LTI) systems in state form has traditionally focused on implementations that require the least number of state variables. Such minimal designs have attempted to limit the requires resources, such as hardware, computation time or power, by minimizing the system dimension. In recent years, however, the increasing necessity for the design and implementation of fault-tolerant systems has proved that "controlled redundancy" (that is, redundancy that has been intentionally introduced in some systematic way) can be extremely important: it can be used to detect and correct errors or to guarantee desirable performance despite hardware or computational failures. Modular redundancy, the traditional approach to fault tolerance, is prohibitively expensive because of overhead in replicating the hardware. This paper discusses alternative methods for systematically introducing redundancy in LTI systems in state form. Our approach consists of mapping the state space of the original system into a redundant space of higher dimension while preserving, within this larger space, the properties of the original system in some encoded form. We provide a complete characterization of the class of appropriate redundant LTI systems and illustrate through several examples ways in which our framework can be used for achieving fault tolerance.

TP3 Linear Systems I

TP3-4

An Integrated Framework for Input, Output and Control Structure Selection: Advanced Control Diagnostics

N. Karcanias, J. Leventides, E. Milonidis

Abstract

This paper aims at formulating an integrated approach to the overall problem of control structure selection and identifying open issues and problems. It is based on the assumption that there exists a progenitor model of the linear type for the process, which however may not be well defined. We then use structural analysis of the system theoretic framework, the interaction measures and the results for the evaluation of alternative decentralization schemes, to specify a step by step approach to the control structure selection. The problem of handling alternative criteria is also considered and basic elements of a system procedure are given. There are many open issues, which are identical and are still open and thus the proposed structural approach should be considered as the first step to the development of an integrated methodology that involves the following major steps: (a) Classification of system model variables and definition of well structured progenitor model. (b) Definition of effective input, output structure based on operability, controllability criteria. (c) Determining the structure of the control scheme by evaluation of alternative decentralized structures. Finally the basics of methodology for sorting out the alternative criteria which may be used in such problem are presented.

TP3 Linear Systems I

TP3-5

System Zeros Analysis via SVD of the First Nonzero Markov Parameter and the Kalman Decomposition Theorem

Jerzy Tokarzewski

Abstract

In this paper we present a complete characterization of system zeros of an arbitrary linear system described by a state-space model $S(A, B, C, D)$. The presented approach is based on singular value decomposition of the first nonzero Markov parameter and the Kalman canonical decomposition theorem. Invariant zeros are treated as the triples: complex number, state-zero direction, input-zero direction. Several numerical examples are discussed.

TP3 Linear Systems I

TP3-6

Constrained Controllability of Dynamical Systems

Jerzy Klamka

Abstract

The present paper is devoted to a study of constrained controllability and controllability for linear dynamical systems if controls are taken to be nonnegative. In analogy to the usual definition of controllability it is possible to introduce the concept of positive controllability. We shall concentrate on approximate positive controllability for linear infinite-dimensional dynamical systems when the values of controls are taken from a positive closed convex cone and the operator of the system is normal and has pure discrete point spectrum. The special attention is paid for positive infinite-dimensional linear dynamical systems. General approximate constrained controllability results are then applied for distributed parameter dynamical systems described by linear partial differential equations of parabolic type different kinds of boundary conditions. Several remarks and comments on the relationships between different concepts of controllability are given. Finally, simple numerical illustrative example is also presented.

TP4 Robot Control

TP4-1

Global Asymptotic Stabilisation of an Active Mass Damper for a Flexible Beam

L. Menini, A. Tornambe, L. Zaccarian

Abstract

In this paper, a finite dimensional approximated model of a mechanical system constituted by a vertical heavy flexible beam with an active mobile mass located at the tip, is proposed; such a model is parametric in the approximation order, so that a prescribed accuracy in the representation of the actual system can be easily obtained with the proposed model. The system itself can be understood as a simple representation of a building subject to transverse vibration, whose vibrating modes are damped by a control action performed at the top by means of a moving mass. A simple PD control law, which requires only the measurement of the relative mass position and velocity with respect to the end-point of the beam, is shown to globally asymptotically stabilize all the flexible modes considered in the approximation model, regardless of the chosen approximation order. Simulation runs confirm the effectiveness of the proposed control law in achieving both position regulation of the mass and vibration control.

TP4 Robot Control

TP4-2

Variable Structure Control of a Robotic Assistance System

M. L. Corradini, T. Leo, G. Orlando

Abstract

The development of an autonomous robotic system for the assistance to disabled people (composed of a 'car-like' mobile base and a robot arm) is the primary aim of the MOVAID Project, supported by the CEC in the framework of the TIDE Programme. In the context of the MOVAID Project, an automatic navigation system is currently being developed at the Robotics Lab at the Dipartimento di Elettronica e Automatica. From the functional viewpoint, the navigation system can be decomposed into a motion planner and a collision avoidance module. Both blocks, however rely on a suitable low-level control procedure, which has to drive the wheel actuators in order to ensure the tracking of the planned trajectory with a sufficient degree of precision, opposing eventual parameter variations and external disturbances. In this paper, a recently developed discrete-time Variable Structure Control (VSC) technique is applied to the control of the steering-wheel robot of the MOVAID Project. The algorithm has been designed in the discrete-time domain, therefore allowing to avoid the well-known problems due to the discretization of continuous-time controllers. The simulation study reported in this note is preliminary to the experimental testing of the control algorithm, which is being carried out.

TP4 Robot Control

TP4-3

Control of Robot Manipulators Using CMAC Neural Networks

S. Commuri, S. Jagannathan, F. L. Lewis

Abstract

A comprehensive treatment of Cerebellar Model Articulation Controller (CMAC) Neural Network (NN) for the control of robot manipulators is presented. The structure and localized learning properties of CMAC NN is exploited to design efficient controllers for nonlinear systems belong to a given useful class. Continuous and discrete-time implementation of these controllers are symmetrically examined. Novel weight update schemes are derived and the closed-loop stability of the controller and the system is rigorously proved. These weight update schemes are shown to be nonstandard modifications of adaptive techniques prevalent in the literature. Finally the validity of these techniques are demonstrated through numerical studies.

TP4 Robot Control

TP4-4

On the Development of a Quick Connect Disconnect Coupler for Rapidly Configured Modular Robots

P. S. Shiakolas, T. W. Sharpe, T. J. Lawley

Abstract

In this paper, we present a novel modular robot connection that provides for the rapid deployment of automation through the quick and rapid configuration of robotic devices based on modules. Modular robots have certain advantages over conventional robots. A modular robot, can be defined as one for which the interchange of link and joint modules quickly occurs with minimal basic adaptations to the base robotic hardware, eliminates many of the flexibility constraints of current robots and re-uses the modules for future configurations. One important component of a modular robot is a Quick Connect/Disconnect (QCD) joint coupler which provides for connection and separation as well as orientation of the individual link-joint-actuator modules. QCD based robots find applications in pilot and prototyping environments, in manufacturing lines with low volume and multi-product production, and on mobile platforms for unstructured manufacturing scenarios such as hazardous material handling and other manufacturing environments.

TP4 Robot Control

TP4-5

Robot Control Using a Sliding Mode

M. Belhocine, M. Hamerlain, K. Bouyoucef

Abstract

The dynamical model of manipulator robot is represented by an equation system which are nonlinear and strongly coupled. Furthermore, the initial parameters of the manipulator depend on the payload which is often unknown and variable. So, to avoid these problems we studied variable structure system which is well suited for robotic arms. To this end, an application of the sliding mode control based on variable structure systems for a four degrees of freedom robot is described in this paper. This technique is applied to the regulation (point to point) control of SCARA robot. So the aim of this work is to show the practical realization and to demonstrate the robustness and the validity of this control law on the robot manipulator via experimental results obtained and discussed in the end.

WA1 Nonlinear Systems

WA1-1

Set-Valued State Observers for Nonlinear Systems

Jeff S. Shamma, Kuang-Yang Tu

Abstract

A set-valued observer (SVO) produces a set of possible states based on output measurements and a priori measurements of exogenous disturbances and noises. Previous work considered linear time-varying systems and unknown-but-bounded exogenous signals. In this case, the sets of possible state vectors take the form of polytopes whose centers are optimal state estimates. These polytopic sets can be computed by solving several small linear programs. A SVO can be constructed conceptually for nonlinear systems, however the set of possible state vectors no longer takes the form of polytopes which in turn inhibits their explicit computation. This paper considers an "extended SVO". As in the extended Kalman filter, the state equations are linearized about the state estimate, and a linear SVO is designed along the linearization trajectory. Under appropriate observability assumptions, it is shown that the extended SVO provides an exponentially convergent state estimate in the case of sufficiently small initial condition uncertainty, and provides a non-divergent state estimate in the case of sufficiently small exogenous signals.

WA1 Nonlinear Systems

WA1-2

State Observers for Linear Systems With Smooth/Bounded Input

A. Germani, C. Manes

Abstract

It is known that for nonlinear systems the drift-observability property (i.e. observability for zero input) is not sufficient to guarantee the existence of an asymptotic observer for any input. Many authors studied conditions on systems structure that ensure uniform observability (i.e. observability for any input). Conditions are available that define restrict classes of uniformly observable systems. This work considers the problem of state observation with exponential error rate for smooth nonlinear systems that do not meet conditions of uniform observability: conditions are given on the input, instead of on the system structure. It is shown that drift-observability, together with a smoothness/boundedness condition on the input, is sufficient to ensure the existence of an exponential observer. Three types of observers are presented, that can be constructed under drift-observability assumption. One works well for systems with maximal relative degree or in the case of input sufficiently small. A second type of observer succeeds for systems with any relative degree in the case of input sufficiently smooth. The input derivatives up to a certain order are required for its implementation. Both observers ensure exponential convergence of exponential error to zero. A third observer suitable in the case of smooth input does not require input derivatives, and ensures exponential decay of the observation error below a prescribed level. Computer simulations close the paper.

WA1 Nonlinear Systems

WA1-3

Parameter Identification of Nonlinear Systems With Known Structure

A. Astolfi, J. J. Milek, F. J. Kraus

Abstract

This paper addresses the problem of on-line parameter estimation for non-linear continuous time dynamical systems of known structure. Two parameter estimation problems are formulated and explicitly solved. The resulting parameter estimation algorithms incorporate an observer; the adjustment of the observer parameters is considered as a stabilization problem for an uncertain system and is solved using sliding mode method. In the full information parameter estimation problem it is assumed that all the system states and their derivatives are known. In the output measurement parameter estimation problem we assume that only one state is known, the other states are reconstructed using an adaptive observer. The proposed algorithm is applied for parameter estimation of a Van der Pol oscillator.

WA1 Nonlinear Systems

WA1-4

Design and Analysis of Incipient Fault Diagnosis Schemes Using On-Line Approximators

Marios M. Polycarpou, Michael A. Demetriou

Abstract

Detection of incipient (slowly developing) faults is crucial in automated maintenance problems where early detection of worn equipment is required. In this note, a general framework for model-based fault detection and diagnosis of a class of incipient faults is developed. The changes in the system dynamics due the fault are modeled as nonlinear functions of the state and input variables, while the time profile of the failure is assumed to be exponentially developing. An automated fault diagnosis architecture using nonlinear on-line approximations with an adaptation scheme is designed and analyzed. A simulation example of a simple nonlinear mass-spring system is used to illustrate the results.

WA1 Nonlinear Systems

WA1-5

On Feedback Linearization Solution

M. Hou, A. C. Pugh

Abstract

Based upon a condensed Brunovsky form, feedback linearization for both single-input and multi-input nonlinear systems is derived in a unified manner. The derivation appears considerably simpler than the known derivations for the multi-input case. A straightforward characterization of the coordinate transformation required in the feedback linearization is provided.

WA1 Nonlinear Systems

WA1-6

On Singular Phenomena in Certain Time-Optimal Feedback System Operating by Discontinuous Resistance

Wladyslaw Hejmo

Abstract

The purpose of this paper is to present the solution of selected time-optimal problems of the controlled object the dynamics of which is given by: $\dot{x} = y$, $\dot{y} = f(x) + u$, where $|u| \leq 1$ and motion resistance function $f(x) = 0$ if $x < 0$, and $f(x) = -A$ if $x \geq 0$ where $0 \leq A < 1$. That model describes dynamics of a very important class of industrial installations.

WA1 Nonlinear Systems

WA1-7

Emergency Control of Unstable Behavior of Nonlinear Systems Induced by Fault

Mark A. Pinsky, Michael V. Basin

Abstract

This paper presents the emergency control approach intended to urgently return to the stability basin the system states affected by abrupt changes in certain system coefficient on a short time interval. Because of its short duration, the modeling of both the fault and controller involves delta- functions significantly simplifying analysis and control of fault phenomena. The design of an emergency controller is based on the technique for computing fault-induced jumps of the system states, which is described in the paper. A sample emergency controller instantaneously returning states of a Van-der-Pol system to the stability basin is designed.

WA2 Applications

WA2-1

A Symbolic Sensor for an Antilock Brake System of a Commercial Aircraft

B. Ewers, J. Bordeneuve-Guibe, Corrine Langlois

Abstract

The design of a *symbolic sensor* that identifies the condition of the runway surface (dry, wet, icy, etc.) during the braking of a commercial aircraft is discussed. The purpose of such a sensor is to generate a qualitative, real-time information about the runway surface to be integrated into the future aircraft Antilock Braking System (ABS). It can be expected that this information can significantly improve the performance of ABS. For the design of the symbolic sensor different classification techniques based upon fuzzy set theory and neural networks are proposed. To develop and to verify these classification algorithms data recorded from recent braking tests have been used. The results show that the symbolic sensor is able to correctly identify the surface condition. Overall, the application example considered in this paper demonstrates that symbolic information processing using fuzzy logic and neural networks has the potential to provide new functions in control system design. The paper is part of a common research project between E.N.S.I.C.A. and Aerospatiale in France to study the role of the fuzzy set theory for potential applications in future aircraft control systems.

WA2 Applications

WA2-2

Multivariable Predictive Controller for a Test Stand of Air Conditioning

Cyril Vaucoret, Joel Bordeneuve-Guibe

Abstract

In this paper, a Multivariable Predictive Control (MPC) algorithm is developed and applied to an industrial test stand for aircraft air conditioning systems. This process has to satisfy a very strict specifications sheet over a large operating range in order to simulate the working conditions of the aircraft equipment. Multivariable identification tests have been carried out to model the system and are reported here. Finally, comparisons through simulation studies between the existing PID regulation and the proposed MPC point out a great improvement of performance.

WA2 Applications

WA2-3

Hinf Control Design for an Adaptive Optics System

Nikolaos Denis, Douglas Looze, Jim Huang, David Castanon

Abstract

In this paper we first present a full order Hinf controller for a multi-input, multi-output (MIMO) adaptive optics system. We apply model reduction techniques to the full order Hinf controller and demonstrate that the closed loop system with the reduced order Hinf controller achieves the same high level of performance. Upon closer examination of the structure of the reduced order Hinf controller it is found that the dynamical behavior of the reduced order Hinf controller can be accurately approximated by a single-input, single-output (SISO) transfer function multiplied by the inverse of the adaptive optics plant dc gain. This observation then leads to a general design methodology which only requires the synthesis of a SISO Hinf controller and multiplication by constant matrices.

WA2 Applications

WA2-4

Optimal Fixture Design for Drilling in Elastically Deforming Plates

K. Wardak, U. Tasch, P. G. Charalambides

WA2 Applications

WA2-5

Development of Mold Level Controller Using Sliding Mode Control in Continuous Casting Processing

Seung Ryeol Yoo, Young Seub Kueon

Abstract

A sliding mode control was applied to mold level control in the continuous casting process. The parameters of the mathematical model are obtained by simulation with the data measured in POSCO's no.2 caster and adjusted through on-line test. The new controller based on VME bus system has parallel interface with a conventional controller. The sliding gate can be controlled by the controller selected between the developed and the conventional controller. Developed controller takes account of casting speed, tundish weight, mold width and etc. the deviation magnitude of the mold level was reduced by the developed controller.

WA2 Applications

WA2-6

Modeling and Simulation of Blood Pump for Controller Development

Yih-Choung Yu, James F. Antaki, J. Robert Boston, Marwan Simaan, Phil J. Miller

Abstract

A mathematical model describing pressure-volume relationship of the Novacor left ventricular assist system (LVAS) was developed. The model consisted of lumped resistance, capacitance, and inductance elements with one time-varying capacitor to simulate the cyclical pressure generation of the system. The ejection and filling portions of the pump cycle was modeled with two separate functions. The corresponding model parameters were estimated by least squares fit to experimental data obtained in the laboratory. The model performed well at simulating pump pressure of operation throughout the full cycle. Computer simulation of the pump with a cardiovascular model demonstrated the interaction between the LVAS with the cardiovascular system. This model can be used to incorporate on-line cardiovascular parameter estimation and to design a new controller for the LVAS.

WA2 Applications

WA2-7

The Control and Structures Research Laboratory (CSRL): A Control-Oriented Test-Bed for Large Segmented Reflectors

Majdedin Mirmirani, Helen R. Boussalis, Khosrow Rad, Mohluddin Ahmed, Anastasios Chassiakos, Petros Ioannou, Elias Kosmatopoulos

Abstract

Because of the weight and volume constraints of space-borne instruments segmented reflectors have become only the practical choice for future astrophysical missions. While a monolithic reflector depends on the mechanical properties of its material to provide the dimensional stability required for good optical performance, a segmented reflector requires an active segment-alignment control system in order to make the reflecting surface have the optical performance of a monolithic unit. This paper describes an experimental test-bed that is being developed at the Control and Structures Research Laboratory (CSRL) at California State University, Los Angeles (CSULA). The CSRL test-bed is a 2.4m focal length Cassegrain optical configuration consisting of a 2.66m actively controlled segmented primary and an active secondary. The primary consists of six hexagonal panels surrounding a fixed central panel and supported by a light-weight flexible truss structure. The project has been founded by NASA to study the complex dynamic behavior of large segmented optical systems.

WA3 Linear Systems II

WA3-1

I1-Optimal Control for Multirate Systems Under Full State Feedback

Johannes Aubrecht, Petros G. Voulgaris

Abstract

This paper considers the minimization of the ℓ_{∞} -induced norm of the closed loop in linear multirate systems when full state information is available for feedback. A state-space approach is taken and concepts of viability theory and controlled invariance are utilized. The essential idea is to construct a set such that the state may be confined to that set and that such a confinement guarantees that the output satisfies the desired output norm conditions. Once such a set is computed, it is shown that a memoryless nonlinear controller results, which achieves near-optimal performance. The construction involves the solution of several finite linear programs and generalizes to the multirate case earlier work on linear time-invariant systems (LTI).

WA3 Linear Systems II

WA3-2

Ellipsoidal Bounding in Stable Predictive Control

M. Cannon, B. Kouvaritakis

Abstract

Efficient algorithms for approximate minimization of constrained infinite horizon predictive control costs are presented. The resulting control laws have guaranteed stability and asymptotic tracking, and comparable performance with existing QP-based control laws.

WA3 Linear Systems II

WA3-3

Constrained Stable Predictive Control: An I2-optimal Approach

B. Kouvaritakis, J. A. Rossiter, M. Cannon

Abstract

Perturbations on I2-optimal solutions are used for the derivation of efficient/feasible predictive algorithms.

WA3 Linear Systems II

WA3-4

The Performance of Generalized Minimum Variance System Identification

Odell R. Reynolds, Meir Pachter

Abstract

In this paper, a comparison is made between the novel Generalized Minimum Variance and established generalized Least Squares estimation algorithms. The emphasis of the Generalized Minimum Variance algorithm is on the proper treatment of measurement noise for dynamical system identification. The algorithms are compared in a carefully performed, reproducible experiments which include measurement noise. Differences are apparent under small measurement samples, but the two appear to produce statistically similar results asymptotically.

WA3 Linear Systems II

WA3-5

Weighted Hinf Mixed-Sensitivity Minimization for Stable Distributed Parameter Plants Under Sampled-Data Control

Delano R. Carter, Armando A. Rodriguez

Abstract

This paper considers the problem of designing near-optimal finite-dimensional controllers for stable multiple-input multiple-output (MIMO) distributed parameter plants under sampled-data control. A weighted Hinf-style mixed-sensitivity measure which penalizes the control is used to define the notion of optimality. Controllers are generated by solving a "natural" finite-dimensional sampled-data optimization. A priori computable conditions are given on the approximations such that the resulting finite-dimensional controllers stabilize the sampled-data controlled distributed parameter plant and are near-optimal. The proof relies on the fact that the control input is appropriately penalized in the optimization. This technique also assumes and exploits the fact that the plant can be approximated uniformly by finite-dimensional systems. Moreover, it is shown how the optimal performance may be estimated to any desired degree of accuracy by solving a single finite-dimensional problem using a suitable finite-dimensional approximant. The proofs and constructions given are simple. Finally, it should be noted that no infinite-dimensional spectral factorizations are required. In short, the paper provides a straight forward control design approach for a large class of MIMO distributed parameter systems under sampled-data control.

WA3 Linear Systems II

WA3-6

On Sampled-Data Control Systems With Discontinuous Output

Marian J. Blachuta

Abstract

Discrete-time models of sampled-data control systems are addressed when both a continuous-time plant and a discrete-time controller have feedthrough. It is pointed out that in this case discrete-time models which can be found in most references should not be used in the closed-loop context. A new state-space model appropriate for the closed-loop modeling, and formulae for calculating the related discrete-time pulse transfer functions are derived. Intersample phenomena are studied and the feasibility of that model to describe systems with parasitic dynamics is emphasized. Examples from the literature illustrate the relevance of the issue.

WA4 Automotive Systems

WA4-1

Macroscopic Traffic Flow Modeling of Automated Highway Systems

H. Raza, P. Ioannou

Abstract

An accurate macroscopic traffic flow model of automated highways is necessary not only for analyzing the collective dynamical behavior of automated vehicles but also for designing control laws to improve system level performance. In this paper a macroscopic model for describing the traffic flow on automated highways is developed by using the microscopic control laws that govern the motion of individual vehicles. Some assumptions were used to derive the instantaneous speed and density profiles from the kinematics of individual vehicles. We have given enough structure to the modeling task, so that the model is independent of the implementation details, hence can be applied to a wide variety of automated highway concepts. The developed model can be used to analyze the steady state behavior of AHS traffic flow for different operating conditions and is currently under study. We plan to use the results of this analysis as guidelines for designing macroscopic as well as microscopic control laws.

WA4 Automotive Systems

WA4-2

Robust Prevention of Limit Cycles for Robustly Decoupled Car Steering Dynamics

Juergen Ackermann, Tilman Buente

Abstract

Considerable safety benefits are achieved by robustly decoupling the lateral and yaw motions of a car with active steering. Robust unilateral decoupling requires an actuator to generate an additional front wheel steering angle. However, introducing actuators to closed loop systems may cause undesired limit cycles due to actuator saturation and rate limits. By introducing a simple nonlinear modification of the control law, this paper proposes a remedy to prevent limit cycles for robustly decoupled car steering dynamics. The robustness of the resulting system w.r.t. the avoidance of limit cycles is investigated for varying operating conditions by combining the parameter space approach and the theory of describing functions.

WA4 Automotive Systems

WA4-3

Modular Design for the Computation of Vehicle Dynamic Behavior

R. Majjad, U. Kiencke

Abstract

In the last years many efforts have been done to develop simulation models. These models need a lot of computational time. This paper presents a new modular simulation to avoid these problems. This approach requires a good tire model to take the nonlinearities into account which have a significant influence on the dynamic behavior of the car. The process of composing the model is modular and consists of several sub-models (tires, chassis, suspension, steering, wind, road). Each of them can be developed independently. The advantage of the simulation is the reduction of time and costs for designing and engineering different controller concepts or vehicle safety systems. It will be proved with different examples that this simulation gives good results for the realistic behavior of the vehicle. The time of simulation is reduced by minimizing the coordinate transformations.

WA4 Automotive Systems

WA4-4

Identification of Parameters for Complex Vehicle Models

R. Majjad, M. Hafner

Abstract

In the last years many efforts have been done to develop simulation models. These models need a large amount of parameters. Many of these parameters are unknown and difficult to measure. A precise knowledge of interior parameters of the car is necessary to be able to make a model which delivers accurate and reliable results. This paper presents the identification of some important parameters concerning the dynamical behavior of the vehicle. These parameters are the load slope ε and the moments of inertia J_x , J_y , J_z for the x-, y- and z-axis and the mass of the chassis. To achieve this goal, a non-linear observer will be used to calculate and to validate the wheel forces which are needed as input values for an estimator. The five parameters are estimated using a RLS method. According to measurements in a test car our method delivers a very good estimation for the behavior of the vehicle.

WA4 Automotive Systems

WA4-5

Fuzzy Parking and Point Stabilization: Application Car Dynamics Model

S. Bentalba, A. El Hajjaji, A. Rachid

Abstract

The first specific problem in this paper is to park a car to a given goal x-position at right angle starting from a given configuration by controlling the acceleration or deceleration force and steering angle of wheels. After dealing with the parking problem, two fuzzy controllers are proposed, the first generates the steering angle from position and orientation errors of the car, while the second controller generates the acceleration or deceleration force from the generated steering angle and the speed of the car. From these controllers and with a geometric transformation, we design a new control method for the second purpose in this study which consists to stabilize the car to a given goal coordinates and an orientation starting from a given position. Simulation results using dynamics car are successfully performed.

WA4 Automotive Systems

WA4-6

Sliding Mode Control of a Turbocharged Diesel Engine

S. Ouenou-Gamo, A. Benchaib, A. Rachid, M. Ouladsine

Abstract

This study seeks to apply sliding mode control on a turbocharger Diesel engine. A complete physical model followed by a reduced form and taking into account thermodynamics of the different steps of the Diesel cycle has never been proposed in the literature. The study shows the role of the turbocompressor on the cylinder filling during the air intake and the exhaust phases on different engine states through thermodynamically laws. This is an attempt to describe the dynamics of the diesel engine by physical equations. The sliding mode control method is used and a solution to the multivariable system control problem is presented. A compressor power control approach is used and relationships between fluid states in the air intake and the exhaust manifold pressure are discussed.

WP1 Two-Dimensional Systems

WP1-1

A New Method for Computing the Stability Margin of Two-Dimensional Systems

Nikos E. Mastorakis

Abstract

The stability margin of 2-D (two-dimensional) Linear Shift Invariant causal single-input single-output discrete systems is investigated. A new method to compute the stability margin of 2-D continuous systems is considered. Illustrative examples are also included.

WP1 Two-Dimensional Systems

WP1-2

New Stability Test for 2-D Systems

Nikos E. Mastorakis

Abstract

In this paper, a new stability test for two-dimensional (2-D) discrete systems is presented. The proposed test is based on a simple 1-D test which is simpler but equivalent to that of Schur-Cohn. The test can be easily automated via a suitable computer code. Examples are given.

WP1 Two-Dimensional Systems

WP1-3

Reachability and Minimum Energy Control of Nonnegative 2D Roesser Type Models

Tadeusz Kaczorek

Abstract

A new class of nonnegative 2D Roesser type models is introduced. Necessary and sufficient conditions are established for the reachability of the nonnegative 2D Roesser type model for zero boundary conditions. It is shown that the nonnegative 2D Roesser type model having no nilpotent system matrix is unreachable for nonzero boundary conditions. The minimum energy control problem is formulated and solved for the nonnegative 2D Roesser type model with zero boundary conditions. The considerations are illustrated by means of a numerical example.

WP1 Two-Dimensional Systems

WP1-4

Some Results on the Dynamics of 2D Positive Systems

Ettore Fornasini, Maria Elena Valcher

WP2 Adaptive Control

WP2-1

Adaptive Control of Discrete-Time Output-Feedback Nonlinear Systems

Jiaxiang Zhao, Ioannis Kanellakopoulos

Abstract

In adaptive control design for discrete-time output-feedback nonlinear plants, the main obstacle is the lack of effective ways to design estimators for the unmeasured states and the unknown parameters. Since these quantities appear as arguments of arbitrary nonlinear functions, traditional estimation methods cannot be used. To resolve this problem, we propose a new systematic methodology by which one can recover all the necessary information about the unknown part of the system in finite time, so that a control schemes for global stabilization and tracking can be designed for such plants.

WP2 Adaptive Control

WP2-2

An Uncertainty Model Validation Approach to Adaptive Robust Linear Control

Robert E. Kosut

Abstract

It is shown that validation (unfalsification) of the standard robust control design uncertainty model is the natural replacement for system identification when the intended use of the model is robust control. The result is an "uncertainty" tradeoff curve between model uncertainty and disturbance uncertainty. Hence, a family of uncertainty models are unfalsified (validated) from the data record. The family of unfalsified models can be used in an iterative approach to system identification and robust control design. The idea can be applied iteratively to both the plant model and the resulting candidate robust control.

WP2 Adaptive Control

WP2-3

Application of a Multivariable Adaptive Controller with PID Structure to a Wastewater Treatment Plant with D-N Configuration

A. M. Macarulla, J. Florez, J. X. Ostolaza, E. Ayesa

Abstract

In this paper a multivariable adaptive controller with PID structure based on the algorithm developed by Yusof and Omatu (1993) using the Minimum Variance strategy, has been applied to a model of a municipal Wastewater Treatment Plant (WWTP) with nitrification and denitrification processes (D-N configuration). This plant is a non-linear process with low controllability. The aim of the controller is to improve the overall performance of the system. The process must satisfy the quality requirements of the effluent water in terms of its concentrations of nitrates and ammonia. The manipulable variables are the Dissolved Oxygen level in the oxic reactor and the Internal Recycle flow rate. The results presented show the response of the plant and the controller under a seasonal variation of temperature. They prove that the operation of the plant is improved, and running costs are lower.

WP2 Adaptive Control

WP2-4

Adaptive Variable Structure Control of Robot Manipulators With Exponentially Stable Trajectories

H. Yu

Abstract

An adaptive variable structure control approach for the robot manipulators is proposed in this paper. The proposed approach avoids requirement of the uncertain parameter bounds which is adopted in the most robust control methods, and makes the tracking error converge to zero exponentially without requiring any persistent excitation. In addition, the fast parameter variations (e.g. payload variation) are allowed, unlike the conventional adaptive control method which assumed that the parameter variations are slower than the adaptive mechanism.

WP3 Linear Systems III

WP3-1

Normalized Coprime Factorizations for Discrete-Time Periodic Systems

Baohui Xie, Vassilis I. Syrmos

Abstract

In this paper the notation of Normalized Coprime Factorization (NCF) for linear discrete-time periodic systems is studied. These systems arise in the study of linear time-varying systems with periodic coefficients. The problem is approached by the study of the original linear periodic state space representation of the system instead of its linear time-invariant representation using lifting technique. It is shown that the NCF can be obtained through the solution to Discrete Periodic Riccati Equations (DPRE). The properties of the DPRE are used to study the NCF for the linear periodic systems.

WP3 Linear Systems III

WP3-2

The Tracking and Regulation Problem for a Class of Generalized Systems

Antonio Tornambe

Abstract

The tracking and regulation problem is considered for a class of generalized systems, in case of exponential reference signals and of disturbance functions. First, the notions of steady-state response and of blocking zero, which are classical for linear time-invariant systems, are given for generalized systems. Then, the tracking and regulation problem is stated and solved for the class of generalized systems under consideration, giving a general design procedure. As a corollary of the effectiveness proof of the design procedure, an algebraic version of the internal model principle is stated for generalized systems.

WP3 Linear Systems III

WP3-3

Dynamic Output Feedback Stabilization for a Class of Saturated Linear Systems

M. Klai, Y. Ait-Amirat

Abstract

This paper addresses the problem of the global stabilization of a linear system with saturating controls by means of a dynamic output feedback using a saturated linear controller built from an observer. It is shown that a simple linear control law of an optimal-like type always globally stabilizes the closed-loop system when the linear system to be controlled is asymptotically or critically stable.

WP3 Linear Systems III

WP3-4

Stabilization Independent of Delay for Saturated Linear Systems

M. Klai, Y. Ait-Amirat

Abstract

This paper deals with the problem of global stabilization independent of delay for a class of delayed linear systems subject to bounded controls. A new sufficient condition addressing the global asymptotic stabilization (G.A.S.), via saturated (static or dynamic) feedback, of such class of systems is proposed. It concerns the class of systems for which the open-loop system without time-delay term is Hurwitz.

WP3 Linear Systems III

WP3-5

Design of L.Q.G. Dissipative Controllers Using Linear Matrix Inequalities

R. Drai

Abstract

We present an application of the Linear Matrix Inequality approach to robust control to the design of multivariable L.Q.G. controllers verifying various sector conditions that generalize existing results concerning positive real systems. The main result is illustrated by considering robust attitude control of a telecommunication satellite in an acceleration maneuver.

WP4 Digital Signal Processing II

WP4-1

An Application of the EM Algorithm to Sequence Estimation in the Presence of Tone Interference

Quan G. Zhang, Costas N. Georgiades

Abstract

For a direct-sequence spread-spectrum (DS-SS) system we pose and solve the problem of maximum-likelihood (ML) sequence estimation in the presence of narrowband interference, using the expectation-maximization (EM) algorithm. It is seen that the iterative EM algorithm obtains at each iteration an estimate of the interference which is then subtracted from the data before a new sequence estimate is produced. Both uncoded and trellis coded systems are studied, and the EM-based algorithm is seen to perform well, outperforming a receiver that uses an optimized notch filter to remove the interference, especially for large interference levels.

WP4 Digital Signal Processing II

WP4-2

A Nonlinear Filtering Algorithm for the Measurement of Rainfall Drop Size Distribution

Takis Kasparis, John Lane

Abstract

Using an impulse suppression algorithm, environmental noise such as thunder and wind can be filtered from the sound of raindrops impacting an acoustic rain gauge sensor. A non-linear filter algorithm, based on a gated median filter, was previously used to suppress scratch noise from damaged phonograph records. The goal of this work is to adapt this impulse suppression algorithm and evaluate its performance in detecting and filtering the impulse signal from a sensor element of the Acoustic Rain Gauge Array at the University of Central Florida. In this case, the amplitude of each impulse is a measurement of the raindrop size impacting sensor. By subtracting the filtered signal from a delayed version of the original, the output signal contains only the drop impulses from which the raindrop size impacting the

WP4 Digital Signal Processing II

WP4-3

Invariant Line Matching Theory of Consecutive Images


Djemma Kachi, Xiao-Wei Tu

Abstract

This paper presents a general line matching method based on geometrical invariants. A line segment is characterized locally by invariant parameters under the group of displacements within an image and the scale changes. Matching is achieved through two steps, features clustering and hypothesis verification. In order to be matched, a pair of lines represented by neighboring features must satisfy geometrical constraints (relative angle and distance) in the image plane. Experiments have shown an high rate matching of different types of images. this is due to the stability of the used line invariants which lead to few hypotheses of matching, as well as the verification using geometrical constraints. Tests conducted on different images sequences have shown efficient matching of images and parts of scenes.

Manuscript Not Available

To jump to a topic by using its bookmark:

1 Click the Bookmarks and Page button  or choose View > Bookmarks and Page to display bookmarks in the overview area. If a triangle appears to the left of the bookmark, click the triangle to show or hide subordinate bookmarks.

2 To go to the destination specified by a bookmark, click the bookmark text or double-click the page icon to the left of the bookmark name. A bookmark can also change the page view, play a movie, reset a form, or perform other actions.

How to use this online guide

Use these procedures to navigate through this guide:



Click underlined text to go to the topic indicated. Underlined text indicates text that is “linked” to another part of this guide. For example, see [Browsing through documents](#) for more information on how to page through Acrobat documents.



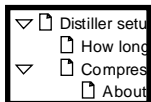
Click the Go Back button in the toolbar to return to your previous location.



Click the Next Page button in the toolbar to go to the next page of the guide.



Click the First Page button in the toolbar to return to the opening screen of this guide.



Click the bookmark name to go to the topic marked by that bookmark. Click the triangle to the left of a bookmark to show and hide subordinate bookmarks. The bookmarks for this guide provide a complete list of topics.



Click the arrow button to go to the next screen of any continued topic.

Opening an Acrobat document

Choose Open from the File menu to open an existing Acrobat document. In the Open File dialog box, highlight the filename, and click Open. Acrobat documents have the extension .pdf (for example, pdfmark.pdf). You can also open an Acrobat document by double-clicking its icon from the Finder (Macintosh) or from the File Manager (Windows).

When you start Acrobat Exchange or Reader, the Open File dialog box appears for you to select a file.

Tools and buttons

The toolbar contains tools for selecting, viewing, annotating, and linking documents. Select a tool by clicking the tool icon.

To hide or show the toolbar, choose Hide Toolbar or Show Toolbar from the Window menu. The command alternates between the two options.

The toolbar contains the following tools and buttons:



The **Page Only** button closes the overview area of the window.



The **Bookmarks and Page** button opens the overview area and displays bookmarks created for the document. Click a bookmark's name to go to the location marked by that bookmark. See [Using bookmarks](#) for more information.



The **Thumbnails and Page** button opens the overview area and displays thumbnail images of each document page. Click a thumbnail to go to the page marked by that thumbnail. See [Using thumbnails](#) for more information.





The **hand** tool enables you to move a single document page on the screen when the page does not fit within the main window. Drag the hand tool in the direction you want to move the page.



The **zoom** tools magnify and reduce the page display. See [Magnifying the page view](#) for more information.



The **select text** tool enables you to select text in a document. This text can then be copied to the Clipboard by using the Copy command. See [Copying text to the Clipboard](#) for more information.



The **select graphics** tool (located in the Tools menu) selects graphics in a document. These graphics can then be copied to the Clipboard by using the Copy command. See [Copying graphics to the Clipboard](#) for more information.



The **note** tool lets you add notes to a document. (If the note tool does not appear in the toolbar, choose Full Menus from the Edit menu.) See [Using notes](#) for more information.





The **link** tool enables you to create or modify a link between two parts of any PDF document or between two PDF documents. (If the link tool does not appear in the toolbar, choose Full Menus from the Edit menu.) See [Using links](#) for more information.



The **article** tool (located in the Tools menu) enables you to define automatic text flows, or articles, to guide readers through documents. See [Creating articles](#) for more information.



The **Previous Page** and **Next Page** buttons move the document backward or forward one page at a time. See [Browsing through documents](#) for more information.



The **First Page** and **Last page** buttons move the document to the first or last page of a document. See [Browsing through documents](#) for more information.



The **Go Back** and **Go Forward** buttons retrace your steps through a document, moving to each view in the order visited. Go Back also returns you to the original document when you click a link to another document. See [Browsing through documents](#) for more information.





The **Actual Size** button displays the page at 100 % magnification.



The **Fit Page** button scales the page to fit within the window.



The **Fit Width** button scales the page to fill the width of the window. Holding down Control (Windows) or Option (Macintosh) and clicking the Fit Width button scales the page so that the visible text and graphics fit the width of the window.



The **Find** button searches for part of a word, a complete word, or multiple words in a document. See [Finding words](#) for more information.



The **Search** button searches indexed PDF documents for single words, phrases, or combinations of words. See [Searching indexed document collections](#) for more information.



The **Search Results** button displays the results of your cross-document search.





The **Search Next** button displays the next occurrence of a search term found by the search tool.



The **Search Previous** button displays the previous occurrence of a search term found by the search tool.



The **Web Browser** button starts your Web browser. If your Web browser is already running, it becomes the active application. (If the Web Browser button does not appear in the toolbar, make sure you have the Weblink plug-in installed.) See [Using Web links](#) for more information.



The **Movie** tool enables you to add digital movies and sounds to your PDF document. (If the movie tool does not appear in the toolbar, make sure you have the Movie plug-in installed.) See [Using the movie tool](#) for more information.

Status bar fields and controls

The status bar contains the following fields and controls:



The **window splitter** lets you adjust the width of the overview and document areas. Drag the control to where you want to divide the two areas.



The **page number box** displays the current page number and lets you go to a specified page in a multipage document. To move to a page, click the page number box to display the Go To Page dialog box, enter the page number, and click OK.



The **magnification box** displays the current page magnification and lets you select various magnifications and page views. To select a custom magnification, choose Other from the menu and enter the value in the Zoom To dialog box. See [Magnifying the page view](#) for more information.



The **page size box** shows the size of the current page by using the units specified in the Preferences dialog box.

Displaying information about a document

The Document Info submenu in the File menu contains commands that display general, font, open, and security information about a document. As a document reader, you may want to refer to this information. When you create a document, you can set attributes that determine how the document is displayed when it opens.

The General Info dialog box consists of four document attributes that the document creator can enter or modify in text boxes: Title, Subject, Author, and Keywords. This data, which is analogous to a card catalog entry, can be used for searches of libraries of PDF documents indexed by using Acrobat Catalog. Document readers can use the Search command in Acrobat Exchange to search indexed PDF documents quickly for single words, phrases, parts of words, or combinations of words. For information on how to use the Search command, see [Searching indexed document collections](#).

Note: *The title is the document's title, not the filename (unless the title and filename are identical).*



In addition to the modifiable document data, the Document Info dialog box displays document attributes set by Acrobat PDF Writer or Acrobat Distiller:

- **Creator** indicates the program that created the document (if known).
- **Producer** indicates the application or driver that produced the PDF document.
- **Created** indicates date and time the document was created.
- **Modified** indicates date and time the document was modified.

The Font Information dialog box describes the font attributes for the current document. To see a list of all fonts used in the document, click the List All Fonts button.

The Open Information dialog box enables you to specify how the document is displayed when it opens. The document can be set to open full screen and at a page other than the first. You can also have the document open with or without bookmarks or thumbnails, and you can set the magnification level for the entire document.



Enter the page on which the document should open in the Go To Page text box. If you want to change the document's original magnification level from the default—the application's default magnification setting when opening the document—select another value from the menu. The values are the same as those in the magnification box. Any other value you select overrides the default and will cause the document to open with another magnification, such as Fit Page.

The Security Information dialog box, which is not editable, indicates the document's security status. See [Setting document security](#) for more information.

Displaying documents in full-screen mode

Document readers can select Full Screen from the View menu so that the PDF document fills the entire monitor screen (similar to a television image).

Document creators can set PDF documents to open in full-screen mode by choosing Document Info/Open from the File menu and then clicking the Full Screen option in the Open Info dialog box. The Full Screen setting can be used for documents that are to be displayed as slide shows with automatic page turning, or for documents that page continuously on kiosks.

The characteristics of full-screen documents—page advancement and background color—are set through the Full Screen Preferences dialog box. See [Full-screen preferences](#) for more information.

A limited set of keyboard accelerators is active in full-screen mode—primarily those related to page navigation and view magnification. The pointer remains active during full-screen mode so that users can click links and open notes.



Thumbnails or bookmarks are not accessible in full-screen mode. If a link forces the opening of a PDF file whose Open attribute is to display bookmarks or thumbnails, only the page will be displayed. The document's Open attributes for page and view magnification, however, will be maintained.

The tools and commands in the following menus are accessible through their keyboard shortcuts:



- The **View menu** includes all commands except Page Only, Bookmarks and Page, and Thumbnails and Page.
- The **Tools menu** includes the hand, zoom-in, and zoom-out tools.

To exit from full-screen display mode, press the Escape key or advance past the last page.

Magnifying the page view

You can use the zoom tools or the magnification box in the status bar to change the screen magnification.

To use the zoom tools:

- Click the zoom-in tool  to double the magnification.
Click the zoom-out tool  to halve the magnification.
- To magnify or reduce a selected area, select a zoom tool and drag the mouse to draw a rectangle around the area you want to view. With the zoom-in tool, the page view expands to show just the contents of the rectangle. With the zoom-out tool, the current page view reduces to fit within the rectangle.
- To toggle between the zoom-in and zoom-out tools, press Control (Windows) or Option (Macintosh).



To use the magnification box:

Move the pointer over the magnification box in the status bar, and press the mouse button. Select a magnification level from the list, or select one of the following:

- **Fit Page** scales the page to fit within the main window.
- **Fit Width** scales the page to fit the width of the main window.
- **Fit Visible** fills the window with the page's imaged area only (text and graphics).
- **Other** sets the magnification to the value entered in the Zoom To dialog box.

When you select any of the Fit options, the current magnification level is displayed in the status bar.

The zoom options, Fit Page, Fit Width, and Fit Visible are in a *sticky state*, which means they don't change as you page through a document, unless you change the zoom. A sticky zoom state is indicated by a check mark next to the item in the View menu, and the item is selected in the toolbar.



To cancel a sticky zoom state:

Choose one of the following options:

- Click the Fit Page or Fit Visible button in the toolbar.
- Select an explicit zoom magnification level, including Actual Size (100%).
- Select a thumbnail zoom.
- Go to a link whose destination includes a specific magnification.

Browsing through documents

The Acrobat Exchange program provides a number of ways to browse through a document.

To page through a document:



Click the Previous Page ◀ or Next Page button ▶ to move back or forward one page. You can also use the Previous Page and Next Page commands in the View menu or the Left Arrow (or Up Arrow) and Right Arrow (or Down Arrow) keys on your keyboard. Use the PageUp or PageDown key on the keyboard to move forward or back one screenful at a time. (If your keyboard doesn't have PageUp and PageDown keys, press Return for PageDown and Shift+Return for PageUp.)

Use the vertical scroll bar to scroll forward and back through a document. As you drag the scroll box, a box to the left of the scroll bar displays the current page number. Click above or beneath the scroll box to move back or forward one screenful.

Use the horizontal scroll bar in the status bar to scroll the page right or left.





To jump to a specified page:

Click the First Page  or Last Page button  to move to the first or last page of a document. You can also use the First Page and Last Page commands in the View menu or the Home and End keys on the keyboard.

Click the page number box in the status bar at the bottom of the main window, or choose Go To Page from the View menu to open the Go To Page dialog box; then enter the page number you want, and click OK.

You can also use thumbnails and bookmarks in the overview area to jump to specified pages. See [Using thumbnails](#) and [Using bookmarks](#) for more information.

To retrace your steps in a document:

Click the Go Back  and Go Forward  buttons to retrace your steps through a document, one view at a time. You can also use the Go Back and Go Forward commands in the View menu.




Note that Go Back returns you to your previous page view. Your previous page view might be the previous page or screen, or it might be a reduced or magnified view. Your previous page view might also be the page view before you scrolled by using the scroll bars or hand tool.

Go Back is useful for recovering from navigational mistakes. If you zoom in or out by mistake, or if you jump to the wrong page, click Go Back to undo your action. You can use the Go Back feature to retrace up to 60 previous views.

Go Forward reverses direction and returns you, one view at a time, to the view where you first used Go Back.


To return to a previous document:

After you click a link or bookmark that takes you to another document, click Go Back  or choose Go Back from the View menu to return to the previous document.


Using thumbnails

Thumbnails are miniature page views that can be displayed in the overview area. You can use thumbnails to jump quickly to a page; to adjust the view of the current page; and to move, insert, and delete pages.

To browse by using thumbnails:

Click the Thumbnails and Page button  or choose View > Thumbnails and Page to display thumbnail images of each page in the document in the overview area. Click a thumbnail to move to that page. The location you click determines the center of the page display.

To adjust the page view:

- Use the hand tool  to drag the page-view box (the light-gray box) on the thumbnail to move around the current page.
- Drag the lower right corner of the page-view box to reduce or expand the view of the current page.
- Position the pointer anywhere outside the current page-view box and drag to draw a new box.



Editing pages by using thumbnails

You can use thumbnails to move, copy, insert, replace, and delete pages. To move or copy a page by using a thumbnail, you must first select the thumbnail.

To select thumbnails:

Click the thumbnail page-number box; Shift-click to select additional thumbnails. A black rectangle appears around a selected page.

To deselect thumbnails:

Click outside a black rectangle to deselect all thumbnails. Shift-click the page number box to deselect one of multiple selected thumbnails.

To move pages within a document:

Select one or more thumbnails, and drag them to the new location. A page icon appears at the tip of the pointer, and a black bar appears above or to the left of the new position. When you release the mouse button, the moved pages are inserted and all subsequent pages are renumbered.



Understanding zoom options

When you select any of the zoom options, Fit Page, Fit Width, or Fit Visible, the magnification is retained throughout the document until you change it. Because these zoom options persist as you page through a document regardless of any previously set magnification, they are referred to as *sticky*. If you open a new document that has no document-level zoom preference, the application's Default Magnification preference setting is used.

A sticky zoom state is indicated by a check mark next to the command in the View menu, and its associated button in the toolbar is highlighted. Clicking the Fit Page or Fit Width button in the toolbar when it is in its sticky state unsticks it. (The Actual Size button is never highlighted; the fact that the document is being viewed at its actual size is indicated by the 100% shown in the status bar.)

Selecting a zoom magnification of a specific percentage, including Actual Size (100%), cancels the sticky zoom state.



Default magnification for bookmarks and links

When you create a new bookmark or link, its default magnification setting depends on whether you are viewing the document in a sticky zoom mode (using one of the Fit options) or not. If you are, the default magnification is this setting. If the view is not a sticky zoom option, the magnification defaults to the last-used nonsticky zoom option: Fixed, Fit View, or Inherit Zoom.

The Inherit Zoom magnification option tells Acrobat Exchange or Reader to display the destination page at the magnification that the reader is using when they click the link or bookmark. Using this option enables the reader to determine the default magnifications for links and bookmarks as they read. When you create a link, you can select Inherit Zoom as the magnification option in the Create Link dialog box.



To choose the Inherit Zoom magnification option for bookmarks:


- 1** Select the bookmark by clicking the bookmark's page icon.
- 2** Press Ctrl/Command+I to display the Bookmark Properties dialog box.
- 3** Click Set Destination in the dialog box.
- 4** Choose Inherit Zoom as the Magnification, and click Set Action.

Finding words

Use the Find command to search for part of a word, a complete word, or multiple words in a document from the current page to the end of the document. If you select Find Backwards, Acrobat Exchange searches the entire document, starting from the current page.

To search across documents that have been indexed by using the Acrobat Catalog program, use the Search command instead of the Find command. See [Searching indexed document collections](#) for more information.

To search for a word:

- 1 Click the find tool , or choose Tools > Find. The Find dialog box appears.
- 2 Select the Match Whole Word Only option if you want Acrobat Exchange to ignore words that contain the word you enter. Select the Match Case option if you want Acrobat Exchange to find only those words that contain exactly the same capitalization as you enter in the Find dialog box.



- 3** In the Find What text box, enter the text to be found, and click Find. When the program finds the text, the Find dialog box closes and the page containing the text is displayed with the text highlighted.
- 4** To find the next occurrence of the word, press Ctrl/Command+G or reopen the Find dialog box and click Find Again.

Copying text to the Clipboard


You can select text in a PDF document, copy it to the Clipboard, and paste it into a document in another application, such as a word processor. When you select formatted text to be copied to the Clipboard, formatting is maintained at the highest level supported.

Once the selected text is on the Clipboard, you can switch to another application and paste the text into another document. You can also paste the text into a PDF document note or a bookmark.

If the other application supports Object Linking and Embedding (OLE), you can use OLE commands to paste text into an OLE compound document. See [Acrobat and OLE](#) for more information

Note: *If a font copied from a PDF document is not available on the system displaying the copied text, the font cannot be preserved. Helvetica is substituted.*

To select text in single-column format and copy it to the Clipboard:

1 Click the text selection tool , or choose Tools > Select Text. The pointer changes to an I-beam.



2 Choose one of two options:

- If the text is in single-column format, drag to select the text you want to copy.
- If the text is in multiple-column format, hold down Control (Windows) or Option (Macintosh) and drag to select the text you want to copy.

When you release the mouse button, the selected text is highlighted. (To deselect the text and start over, click anywhere outside the selected text.)

3 Choose Edit > Copy to copy the selected text to the Clipboard. To view the text, choose Window > Show Clipboard.

Copying graphics to the Clipboard

You can select a graphic in a PDF document, copy it to the Clipboard, and paste it into a document in another application. If you select part of a page, the bitmap image of the screen is captured at the screen's resolution and copied to the Clipboard as a Metafile (in Windows) or as a PICT file (on the Macintosh).

Once the selected graphic is on the Clipboard, you can switch to another application and paste the graphic into another document.

To select graphics and copy them to the Clipboard:

- 1** Choose Tools > Select Graphics. The pointer changes to a cross hair (+).
- 2** Drag to select the graphic you want to copy. When you release the mouse button, the selected area is highlighted. (To deselect the graphic and start over, click anywhere outside the selected area.)
- 3** Choose Edit > Copy to copy the selected graphic to the Clipboard. To view the selection, choose Window > Show Clipboard.

Search tips

When you begin using the Search command, you might encounter the following two problems:

- A search finds too many documents. A search for a single word can, for example, return hundreds of documents—far too many to open and view.
- A search finds too few, or no documents.

This topic gives advice for solving both of these problems.

Handling a search that finds too many documents

When a search returns too many documents, you can use the following techniques to restrict or refine the results of the search.

- Ignore documents with a medium or low relevance ranking. By default, found documents are listed in order of a [relevance ranking](#). The information you seek might be in the documents with the highest relevance ranking.



- Use AND to limit searches to documents that contain two or more words or phrases. You can search, for example, for documents that contain *North* and *Nicaragua* and *senate hearings*. You can also use NOT to find documents that contain one, two, or more words but not another word. You can search, for example, for documents that contain *human* and *fossil* but not *piltdown*. See [Searching with AND, OR, and NOT](#) for more information about AND and NOT.
- When you use AND to search for documents containing two or more words, you can use the Proximity search option to change the way found documents are assigned a relevance ranking. With the Proximity option selected, the closer together the words are in a document, the higher the relevance ranking. The Proximity option also requires that terms in an AND search be within three or four pages of one another to be found.
- Use the [Refine Search feature](#) to limit a search to the documents returned by a previous search. You can, for example, first find all the documents that contain the phrase *Anaconda project*. Then, by using the Refine option, you can enter any combination of search terms and options, and the search will be limited to only those documents that also contain *Anaconda project*.



- Use field values to restrict searches to only those documents with field values you specify. When searching an index of English literature, for example, you can limit a search to just those documents that have an Author field that contains *Shakespeare* and a Title field that contains *king*.
- Use date ranges to restrict searches to only those documents that were, for example, created before a specific date or modified after a specific date.
- Use the Match Case search option to limit searches to documents that contain the words or phrases that are capitalized exactly like the search word or phrase you enter.

Locating hard-to-find information

If a search returns too few documents, first make sure that the search is set up correctly. Make sure that you are using the index or indexes built for the documents that contain the information you seek. Also, make sure that you don't have search options selected or field values entered from a previous search.




If a search is set up correctly and too few documents are returned from the search, use the following techniques to increase the number of found documents:

- Use the [Word Stemming](#) search option to find words that share a stem with a search word. Searching for *programming*, for example, also finds *program* and *programs*, but not *programmer*. (See [Word Stemming search option](#) for details).
- Use OR to search for alternative spellings of the same word or to search for two or more words that are used to describe the information for which you are searching. When looking for information about political revolutions, for example, you might search for *revolution* or *coup* or *uprising*. See [Searching with AND, OR, and NOT \(Boolean expressions\)](#) for more information about OR searches.
- Use the [Thesaurus](#) search option to find words that have the same meaning as the search word. Searching for *crypt*, for example, also finds *grave*, *mausoleum*, *sepulcher*, and *tomb*.



- Use the [Sounds Like](#) search option to find different spellings of last names. Searching for *Smith*, for example, also finds *Smythe*. (Searching for *Smith*, however, also finds *send* and *somewhat*. See [Using the Word Assistant](#) for a way to use the Sounds Like feature without finding irrelevant terms.)

Starting a search

1 Choose Search > Query from the Tools menu, or click the Search button  on the toolbar.

2 Select one or more indexes. The indexes represent the document collections you want to search.

3 Choose one or more of the following options:

- Enter a search term, phrase, or Boolean expression. You don't have to enter search text; you can perform a search with just Document Info field values or a document creation or modification date range.
- Enter one or more Document Info field values, either to limit your search or to find documents with field values you specify.
- Enter a creation or modification date range, either to limit your search or to find documents created or modified in the periods you specify.
- Choose one or more search options.



4 Click Search to perform the search. Acrobat Exchange searches the index or indexes and displays a list of all the found documents in the Search Results window.

5 View the search results. By default, the documents returned from a search are listed according to a score (or relevance ranking), which places the documents most likely to contain relevant information at the top of the list. Double-click a document title to display the first page that contains a search term in that document. With one of the documents returned from the search displayed, you can use the Search Next and Search Previous buttons to see all the pages containing search terms in all the documents returned from the search.

See Viewing search results for more information.

After performing a search, you can use the Refine feature to perform another search that is limited to just those documents returned by the previous search.

Selecting indexes to search

The Search command searches for words and character sequences in documents that have been indexed by the Acrobat Catalog program. By selecting a single index, you can find words and terms in any document in the collection of indexed documents. By selecting two or more indexes, you can search for words in two or more collections at the same time.

To use an index, you must add it to the list of available indexes. As you search for information, you choose which indexes to search, by selecting and deselecting indexes in the list of available indexes.

To help decide which index to use for your search, you might want to view a description of an index. See [Viewing information about indexes](#) for instructions.

The following pages tell you how to do the following:

[Select indexes for your search](#)

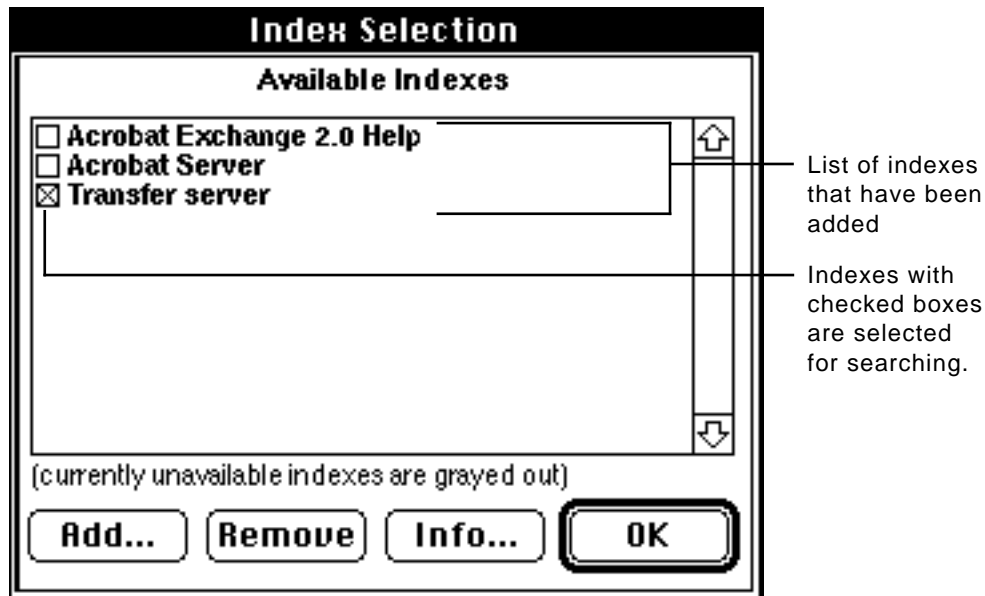
[Add an index to the search list](#)

[Remove an index from the search list](#)



To select one or more document indexes to search:

1 Click the Indexes button in the Acrobat Search window.
Alternatively, choose Search > Indexes from the Tools menu.
The Index Selection dialog box appears.



- 2 Click the check box to the left of the index you want to use.
- 3 Click OK to close the Index Selection dialog box and return to the Search window.

Note: *Dimmed indexes are currently unavailable for searching. Usually, an index is unavailable because the network connection between your computer and the server where the index resides has been lost. See [The index is unavailable](#) for more information.*

To add an index to the search list:

- 1 Select Search > Indexes from the Tools menu, or if the Acrobat Search window is already open, click the Indexes button. The Index Selection dialog box appears.
- 2 Click Add. The Add Index dialog box appears.
- 3 Locate and select the index you want to use. Acrobat index definition filenames end with .pdx.
- 4 Click OK (with Windows) or Open (on the Macintosh) to select the index and close the Add Index dialog box. Alternatively, double-click the name of the index you want to use. The new index is added to the search list.



To remove an index from the search list:

- 1** Click the Indexes button in the Acrobat Search window. Alternatively, Choose Search > Indexes from the Tools menu. The Index Selection dialog box appears.
- 2** Click to highlight the name of the index you want to remove.
- 3** Click Remove. The index is removed from the list.
- 4** Click OK to return to the Acrobat Search window.

Viewing information about indexes

After you have [added an index to the search list](#), you can display the following information about the index:

- **Title** is the index name that appears in the Index Selection dialog box.
- **Description** is the index description written by the publisher who created it.
- **Path** is the location and name of the PDX index file as seen from your computer.
- **Last Built** is the date the index was last updated to include new and changed documents.
- **Created** is the date the index was created.
- **Documents** is the number of PDF documents in the collection of indexed documents.



▪ **Status** indicates the index's current status. *Available* means that you can select the index for searching. *Unavailable* means that Acrobat Search cannot open the index files, usually because the network connection to the server containing the index files has been lost. You cannot search an unavailable index. *Not Loaded* means the index has not been selected; it may or may not be available for searching.

To display information about an index:

- 1 Click the Indexes button in the Acrobat Search window. Alternatively, choose Search > Indexes from the Tools menu. The Index Selection dialog box appears.
- 2 Click to highlight the name of the index in which you are interested.
- 3 Click Info. The Index Information dialog box appears.

Searching for a single term

To find occurrences of single term, enter the term in the Find text box and click Search. A search term can be a word, a word with wild-card characters, or any combination of letters, numbers, and symbols.

You cannot find stopwords, which are words excluded from an index, and you might not be able to find numbers. Contact the person who created the index to learn which words, if any, are excluded from the index and whether numbers are included in the index.

You can use the Match Case, Word Stemming, Sounds Like, and Thesaurus options when searching for a single term. The Match Case, Word Stemming, and Sounds Like options might not be available with all indexes, because index publishers can choose not to add support for these features.

You can also use Document Info and Document creation and modification date field values to limit the number of documents returned by a search for a single term.



See [About Acrobat indexes](#) for a description of how the Acrobat Catalog program recognizes words and other terms in PDF documents and how index publishers can prevent stopwords and numbers from being included in an index.

Searching for a phrase

To search for a phrase, type the phrase in the Find text box and click Search. For example,

status report

finds all occurrences of *status report*, *Status report*, and *Status Report*, as well as all other combinations of uppercase and lowercase letters for the phrase *status report*.

You can use a phrase as part of a Boolean expression. For example,

status report AND anaconda project

finds all documents that contain both the phrase *status report* and the phrase *anaconda project*.

If the phrase you want to find contains a Boolean operator, you must enclose the phrase in quotation marks. For example,

“cats and dogs” OR “rain or shine”

finds all documents that contain either the phrase *cats and dogs* or the phrase *rain or shine*.



Use the [Match Case option](#) to find phrases that are capitalized exactly like the phrase you enter in the Find box.

The [Thesaurus](#), [Sounds Like](#), and [Word Stemming](#) options have no effect on phrase searches.

You can use [Document Info](#) and [Document creation and modification date](#) field values to limit the number of documents returned by a search for a phrase.

Stopwords and phrase searches

Phrases that include [stopwords](#) cannot be found as phrases. For example, if Lincoln's Gettysburg address is indexed with the [typical stopwords list](#)—which includes *of*, *the*, *by*, and *for*—users cannot find the address by searching for its most famous phrase,

Of the people, by the people, for the people
or with
people people people



which is how—with the typical stopwords list—the phrase is indexed. In this case, the only way to find the words in Lincoln's famous phrase is to search for *people*. The limitation that stopwords place on phrase searches is a good reason not to exclude stopwords from an index. However, stopwords reduce the size of an index, which is why they are sometimes excluded from indexes.

Punctuation and other special characters in phrase searches

Acrobat Search ignores any punctuation characters you enter as part of a phrase.

For example, the search phrase *Go home!* finds *Go home!* but it also finds string such as *I want to go home* and *Go home? You must be joking*.

Similarly, Acrobat Search ignores other special characters such as the at sign @ and the asterisk [*] See [How terms are indexed](#) for details.

Searching with wild-card characters

You can use wild-card characters to find all the words that contain a word fragment or all the words and terms that match an arbitrary character pattern. The wild-card characters are the following:

- * the asterisk, which matches zero, one, or more characters
- ? the question mark, which matches any one character

Wild-card examples

- geo* matches words such as *geode*, *geodesic*, *Geoffrey*, *geography*, *geometry*, *George*, and *geothermal*
- *nym matches words such as *antonym*, *homonym*, and *synonym*
- ?ght matches words such as *fight*, *light*, *might*, *right*, and *sight*
- 555-? matches all seven-digit phone numbers with the 555 prefix
- pr?m* matches words such as *premature*, *premeditate*, *prim*, *primate*, *promise*, and *promontory*



You can use wild-card characters in a term that is part of a [Boolean expression](#). You can also use wild-cards to specify [Document Info](#) field values.

Note: *You cannot use wild-card characters to represent separator characters such as the hyphen [-] and the slash [/]. When the Catalog program builds an index, it uses separator characters to recognize where words begin and end and does not place them in the index. To find both begin/end and begin-end, for example, you cannot search for begin&end . Searching for begin&end finds neither begin/end nor begin-end. To find both, you must search for the phrase begin end, or for both begin/end and begin-end. See [How terms are indexed](#) for a description of separator characters.*

Limiting search results with Document Info fields

You can use Document Info field values to limit the results of your searches to just those documents that contain specific field values. To add the Document Info fields to the Search window, choose [Preferences > Search](#) from the Edit menu and select Show Fields in the Preferences dialog box.

With Document Info

Title	<input type="text"/>
Subject	<input type="text"/>
Author	<input type="text"/>
Keywords	<input type="text"/>

When you enter a Document Info field value or [expression](#), only documents with fields that contain the value and that meet the search criteria are returned.



Document Info fields may be empty, because PDF document creators are not required to enter field values. You may also see additional fields not described in this guide, because PDF document creators can add custom fields. If you are using Acrobat Exchange, you can enter or change field values.

When you enter one or more Document Info field values or expressions in the Find text box, you do not have to enter a search term. You can use fields to find all the documents that contain a specified field value.

Note: *The Title field contains a document title that has been entered by the author. For Macintosh documents, it does not contain the Macintosh filename unless the author entered the filename as a title.*



Using two or more fields

Entering values for two or more fields specifies an AND condition. Documents must contain all the field values you specify. For example, if you enter *Samuelson* in the Author field, *cost analysis* in the Subject field, and *spreadsheet* in the Keywords field, only documents that contain these values in these fields are returned from subsequent searches.



Wild-card characters

You can use wild-cards in Document Information text boxes. For example, if you enter

Sm?h*

in the Author text box, documents with Author field values that include Smith, Smyth, and Smythe can be returned with subsequent searches. See [Searching with wild-card characters](#) for instructions on how to use wild-card characters.

Boolean expressions

You can use Boolean expressions in Document Information text boxes. For example, if you enter

Shakespeare or Milton

in the Author text box, only documents that include either Shakespeare or Milton in the Author field are found. See [Searching with AND, OR, and NOT \(Boolean expressions\)](#) for instructions on how to build Boolean expressions.



Boolean expressions that use more than one field

By combining the field expression with the search expression in the Find text box, you can build a Boolean expression that uses more than one field . For example, if you enter

(“Sixteen to one project” OR “16 to 1 project”) AND
(Author ~ Raskin) AND (Keywords ~ “slide show” OR
keywords ~ presentation OR keywords ~ spreadsheet)

in the Find text box, the search returns only documents that

- contain either the phrase *sixteen to one project* or *16 to 1 project* and
- Have an Author field that contains *Raskin*, and
- Have a Keywords field that contains either the phrase *slide show* or the word *presentation* or *spreadsheet*.

The tilde [~]operator is described in the following section.



Operators that can be used only with Document Info fields

Certain operators can be used only in Document Info field values.

Operator	Meaning
=	matches exactly (for text, numeric, and date values)
~	contains (for text values)
≠	does not contain (for text, numeric, and date values)
<	is less than (for date or numeric values)
<=	is less than or equal to (for date or numeric values)
>	is greater than (for date or numeric values)
>=	is greater than or equal to (for date and numeric values)

The comparison operators (<, <=, >, and >=) can be used only with values of the same type. For example, a date value can be compared only with another date value, and a text value can match exactly only another text value.

The standard Document Info fields—Title, Subject, Author, and Keywords—are all type text.

Limiting search results by document creation and modification dates

You can use the Date Info fields to limit search results to just those documents that were created or modified in a specific time period. To add the Date Info fields to the Acrobat Search window, choose Preferences > Search from the Edit menu and select the Show Date option.

With Date Info	mo	dy	yr		mo	dy	yr
Creation after	/	/			before	/	/
Modification after	/	/			before	/	/

To specify a date:

- 1 Click the month field box for the date you want to specify, and enter the number of the month. The current day and year appear in the day and year fields.
- 2 To change the day, click the day field and either enter the day number or use the up and down arrows to select the day number.



3 To change the year, click the year field and either enter the year or use the up and down arrows to select the year.

To limit a search to documents created or modified after a specific date:

Specify the After date, and leave the Before date blank.

To limit a search to documents that were created or modified before a specific date:

Specify the Before date, and leave the After date blank.

To clear the date fields:

Click Clear.

To use both the creation and modification dates:

Entering time periods for both creation and modification dates specifies an AND condition. Only documents created in the specified period and modified in the specified period are returned from a search.

Using search options

The search options expand and restrict the results of searches with single terms, phrases, and Boolean expressions. The search options do not apply to Document Information field values. To add the search options to the Acrobat Search window, choose Preferences > Search from the Edit menu and select Show Options.

Options

<input checked="" type="checkbox"/> Word Stemming	<input type="checkbox"/> Thesaurus	<input type="checkbox"/> Match Case
<input type="checkbox"/> Sounds Like		<input type="checkbox"/> Proximity

- Word Stemming finds words that share a stem with the search term.
- Thesaurus finds words that have the same meaning as the search term.
- Sounds Like finds words that share a phonetic resemblance to a search term.
- Match Case finds only words that are capitalized exactly like the search term.
- Proximity changes AND searches so that words must be within three or four pages of one another.



See also [Using the Refine search feature.](#)

You can use the [Word Assistant](#) to see the effects of using the Word Stemming, Thesaurus, and Sounds Like search options before performing a search. Choose Search > Word Assist from the Tools menu to display the Word Assistant dialog box.

Word Stemming search option

Word stemming expands the search to find words that share word stems with the search terms you enter in the Find box. For example, with Word Stemming selected, searching for *building* finds *build* and *builds* as well as *building*.

Note: *The Word Stemming option does not find words that end with er. For example, searching for build does not find builder, searching for bake does not find baker, and searching for publish does not find publisher.*

Use the [Word Assistant dialog box](#) to see all the words in the current index or indexes that share a stem with a specified search term. Choose Acrobat Search > Word Assist from the Tools menu to display the Word Assistant dialog box.

The Word Stemming feature does not apply to terms that contain [wild-card characters](#).



You cannot use the Word Stemming option with the Match Case option. When Word Stemming is selected, the Match Case option is ignored.

Not all indexes support the Word Stemming option; index publishers must build support for word stemming into indexes. When an index does not support word stemming, selecting the option has no effect.

Thesaurus search option

Thesaurus expands the search to find words that bear some semantic resemblance to the search terms you enter in the Find box. For example, with Thesaurus selected, searching for *begin* finds *start*, as well as *attack*, *produce*, and many other terms.

Sometimes the number of words that the search feature considers to have the same meaning as a given search term is surprising. Before searching with the Thesaurus option, it is usually a good idea to use the Word Assistant to see all the words that the Search feature considers to have the same meaning as a specific search term. Choose Acrobat Search > Word Assist from the Tools menu to display the Word Assistant dialog box.

The Thesaurus feature does not apply to terms in a search phrase or to terms that contain wild-card characters.

You cannot use the Thesaurus option with the Match Case option. When the Thesaurus option is selected, the Match Case option is ignored.

Sounds Like search option

Sounds Like expands the search to find words that begin with the same letter as a search term and that share some phonetic relation to a search term. For example, with Sounds Like selected, searching for *Smith* also finds *Smyth* and *Smythe*. Searching for *Smith*, however, also finds *send* and *somewhat*. Before searching with the Sounds Like option, it is usually a good idea to use the Word Assistant to see all the words that the Sounds Like option will find. To display the Word Assistant dialog box, choose Search > Word Assist from the Tools menu.

The Sounds Like feature does not apply to terms in a search phrase or terms that contain wild-card characters.

You cannot use the Sounds Like option with the Match Case option. When Sounds Like is selected, the Match Case option is ignored.

Not all indexes support the Sounds Like option; index publishers must build support for the Sounds Like option into indexes. When an index does not support Sounds Like, selecting the option has no effect.

Match Case search option

Match Case limits the results of the search to find only those documents that contain words with the same capitalization as the search term or terms you enter in the Find box. With Match Case selected, for example, searching for *He* finds all occurrences of *He*, the symbol for Helium, but not occurrences of *he*, the common pronoun.

You can use the Match Case option with phrase searches, and the Match Case option applies to any terms you use with a Boolean expression.

You can also use the Match Case option with terms that contain wild-card characters. Characters matched by wild-card characters, however, can be either uppercase or lowercase.

You cannot use the Match Case option with the Word Stemming, Thesaurus, or Sounds Like options. When any of these options are selected, the Match Case option is ignored.



Not all indexes support the Match Case option; index publishers must build support for the Match Case option into indexes. When an index does not support Match Case, selecting the option has no effect on searches.

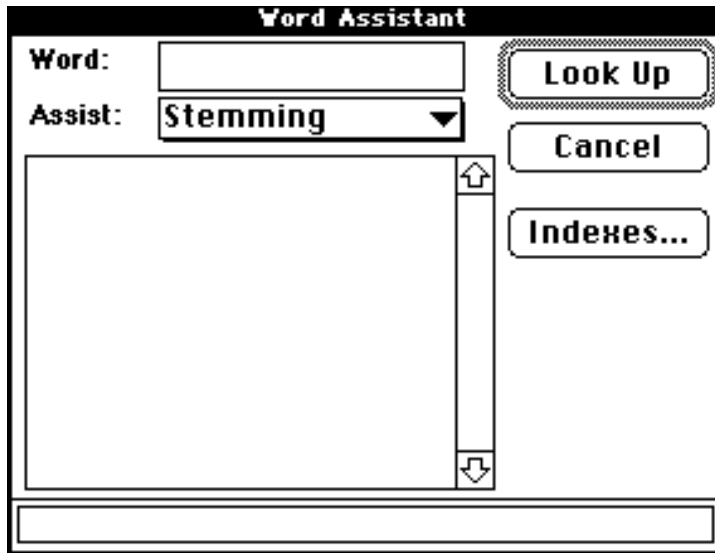
Proximity search option

Proximity changes the way AND searches work. With Proximity selected, words in an AND search must be within two or three pages of each other to be found. Without the Proximity option, two words may appear anywhere in a document and still be found by an AND search.

Also, the closer the words are in the document, the higher the relevance ranking of the document in which they appear.

Using the Word Assistant

The Word Assistant dialog box shows how the [Sounds Like](#), [Word Stemming](#), and [Thesaurus](#) search options affect a search query. Use the Word Assistant to see which terms, in addition to the search term, will be found with a search option selected.



You can also cut terms from the Word Assistant dialog box and paste them into the Search window to construct quickly a list of terms to find. Cutting and pasting terms is especially useful for the long lists of words that are often suggested by the Thesaurus or Sounds Like option.

To see the effects of a search option on a search term:

- 1** Choose Acrobat Search > Word Assist from the Tools menu. The Word Assistant dialog box appears.
- 2** If you do not want to use your current indexes, click Indexes to display the Index Selection dialog box and select the indexes you want to use.
- 3** Select the search option from the Assist menu.
- 4** Enter the search term in the Word text box.
- 5** Click Lookup. All the words that will be found are listed in the scrolling list.



To search with a term listed in the Word Assistant dialog box:

- 1** Click the Search button to display the Search window.
- 2** Choose Search > Word Assistant from the Tools menu to display the Word Assistant dialog box.
- 3** Enter the search term in the Word box, select the search option from the Assist list, and click Lookup. The related words are listed in the list box.
- 4** Double-click a word that you want to use. The word appears in the Word text box.
- 5** Double-click the word in the Word text box to select it, and press Ctrl/Command+C to copy it.
- 6** Click the Search window title to select it; then click the Find text box and press Ctrl/Command+V to paste the selected word into the text box.
- 7** Repeat steps 4 through 6 for each word you want to use; separate each pair of words in the Find text box with OR.

Using the Refine search feature

Refine search restricts the next search to only those documents found by the previous search. Only documents currently listed in the Search Results window are searched.

To use the Refine search feature:

- 1 Use any combination of search terms, Document Info field values, Date Info field values, and search options to perform a search. The found documents are listed in the Search Results window.
- 2 With one or more documents in the Search Results window, click the Search Query button in the toolbar to open the Acrobat Search window.
- 3 Enter any new combination of search terms, Document Info field values, Date Info field values, and search options.
- 4 Press Ctrl (for Windows) or Option (on the Macintosh) and click the Refine button. (Pressing Ctrl or Option with documents in the Search Results list changes the Search button to the Refine button.) The Search Results window lists documents that were previously in the Search Results list and that meet the new search criteria.

Searching with AND, OR, and NOT (Boolean expressions)

You can use AND, OR, and NOT operators to build a Boolean expression that specifies combinations of words that a document must have to be returned by a search.

Suppose, for example, you were searching a collection of U.S. history articles for information about Noah Webster, who wrote the first U.S. American English dictionary. If you searched for *Webster*, you would find references to Noah Webster, but you would also find references to Daniel Webster, a nineteenth century U.S. senator from Massachusetts. To find references to Noah Webster and avoid references to Daniel Webster, you could search for articles that contain *Webster* and *dictionary* but not *congress* or *senate*.

You can also use Boolean expressions in Document Info field text boxes to specify a combination of field values that documents must contain to be returned from a search.



See the following topics for more information about Boolean expressions:

[AND searches](#)

[OR searches](#)

[NOT searches](#)

[Combining Boolean operators](#)

[Using parentheses to change the order of evaluation](#)

[Using operator names and parentheses in a Boolean expression](#)

For information about using Boolean expressions to specify Document Info field values, see also [Searching with AND, OR, and NOT \(Boolean expressions\)](#) or [Limiting search results with Document Info fields](#).

AND searches

Use AND to specify two or more search terms that a document must contain to be returned by a search. For example,

installation AND instructions

finds only those documents that contain both *installation* and *instructions*.

You can also use the ampersand & to specify an AND search. For example,

installation & instructions

also finds documents that contain both *installation* and *instructions*.



Choosing the Proximity search option changes the way AND searches work. Without the Proximity option, terms in an AND search can be anywhere in a document. Searching for *red* and *blue*, for example, can find a document in which *red* is the first word on the first page and *blue* is the last word on the last page. With the Proximity option, however, terms in an AND search must be within two or three pages of each other to be found. Also, with the Proximity option selected, the closer the terms appear together, the higher the relevance ranking of the document that contains them.

OR searches

Use OR to specify two or more search terms, any of which a document can contain and be returned by a search. For example,

television OR tv

finds all documents that contain either *television* or *tv*.

You can also use a comma [,] or a vertical bar [|] to separate terms in an OR search. For example,

television, tv

and

television |tv

also find all documents with either or both *television* and *tv*.

Although any document that contains any term used with an OR operator is returned from a search, documents that contain both terms rank higher in the Search Results list. See [Relevance ranking](#) for more information.

NOT searches

Use NOT to exclude documents that contain a search term. For example,

not quarterly

finds all documents that do not contain the word *quarterly*.

You can also use an exclamation point ! to specify a NOT search. For example,

!quarterly

also finds all documents that do not contain the word *quarterly*.

Note: *You must place a space between the exclamation point and the search term.*

Combining Boolean operators

This topic explains how to combine Boolean operators in a search query.

Caution: *Be careful when combining operators to build Boolean expressions. Unless you work with Boolean expressions frequently, it is easy to build an expression that does not mean what you think it means.*

Combining AND and OR operators

When you combine AND and OR in the same expression, AND is evaluated before OR. For example,

darwin OR origin AND species

finds all documents that contain *darwin* or that contain both *origin* and *species*.



Combining AND, OR, and NOT operators

When NOT is used with either or both of the AND and OR operators, it is evaluated before either the AND or OR. For example,

evolution AND not darwin

finds all documents that contain the word *evolution* but not *darwin*.

Using parentheses to change the order of evaluation

You can use parentheses to change the default order of evaluation for Boolean operators. For example,

(darwin or origin) AND species

finds all documents that contain either *darwin* and *species* or that contain *origin* and *species*. Parentheses can be nested to any depth.

Using operator names and parentheses in a Boolean expression

When you use a phrase that contains operator names or parentheses, the phrase must be enclosed in quotes. For example,

“cats and dogs” OR “cats &dogs”

finds all documents that contain either the phrase *cats and dogs* or the phrase *cats & dogs*.

Similarly, when you use a search term that contains an operator character or parentheses, the term must be enclosed in quotes. For example,

“(cats|dogs)”

finds all documents that contain the term (*cats/dogs*) as well as all documents that contain the phrase *cats dogs*. The phrase *cats dogs* is found because parentheses and the vertical bar are discarded before terms are entered into the index. They are also discarded when a search is performed. See [How terms are indexed](#) for details.



As another example,

“origin of the species” OR “step 36(a)” AND “cats and dogs”
finds all documents that contain the phrase *origin of the species*, or
that contain both the phrase *step 36(a)* and the phrase *cats and
dogs*.

When the following words and characters are used within a phrase,
the phrase must be enclosed in quotation marks:

AND	[AND operators]
OR	[OR operators]
NOT	[NOT operators]


Viewing search results


When you enter a search query, Acrobat Exchange lists in the Search Results window the documents it finds.



To view a document returned from the search:

1 Select the document name, and click View (or double-click the document's name). After opening a document returned from the search, use the Acrobat Search buttons on the toolbar to view all the pages containing search terms.

2 To highlight the next occurrence of a search term, click the Search Next button . When the last occurrence of a search term in a document is displayed, Search Next displays the first occurrence in the next document. Search Next displays documents in the order that they are listed in the Search Results window. Pressing the Shift key and clicking Search Next displays the first occurrence of a search term in the next document.

3 To highlight the previous occurrence of a search term, click the Search Previous button . When there are no more occurrences of a search term in a document, the last occurrence of a search term in the previous document is displayed. Search Previous displays documents in the reverse of the order in which they are listed in the Search Results window. Pressing the Shift key and clicking Search Previous displays the first occurrence of a search term in the previous document.



Changing the order in which found documents are listed

By default, documents are listed in the order of their score or relevance ranking, which places the documents most likely to contain relevant information at the top of the list. With the Acrobat Search Preferences dialog box, you can change the order in which documents are listed. For example, you can sort documents by creation date, by title, or by author. Choose Preferences > Search from the Edit menu to display the Acrobat Search Preferences dialog box.

Changing the way Acrobat Search displays found terms

By default, all the search terms on a page are highlighted and the Search Next and Search Previous buttons display the next and previous pages with found terms. You can, however, change the way found terms are highlighted by changing the Highlight option in the Acrobat Search Preferences dialog box:

- **By Word** highlights search terms one at a time; each click of the Search Next or Search Previous button moves the highlighting from one term to the next.



- **No Highlighting** displays pages with found terms without highlighting terms; each click of the Search Next or Search Previous button displays a new page.

- **By Page**, the default, displays pages with all found terms highlighted; each click of the Search Next or Search Previous button displays a new page.

Choose Preferences > Search from the Edit menu to display the Acrobat Search Preferences dialog box.

Limiting the number of documents returned by a search

By default, Acrobat Exchange lists no more than 100 documents in the Search Results list. You can, however, change this limit to a higher or lower number in the Acrobat Search Preferences dialog box.

The minimum is 1 document; the maximum is 1000 documents.

Choose Preferences > Search from the Edit menu to display the Acrobat Search Preferences dialog box.

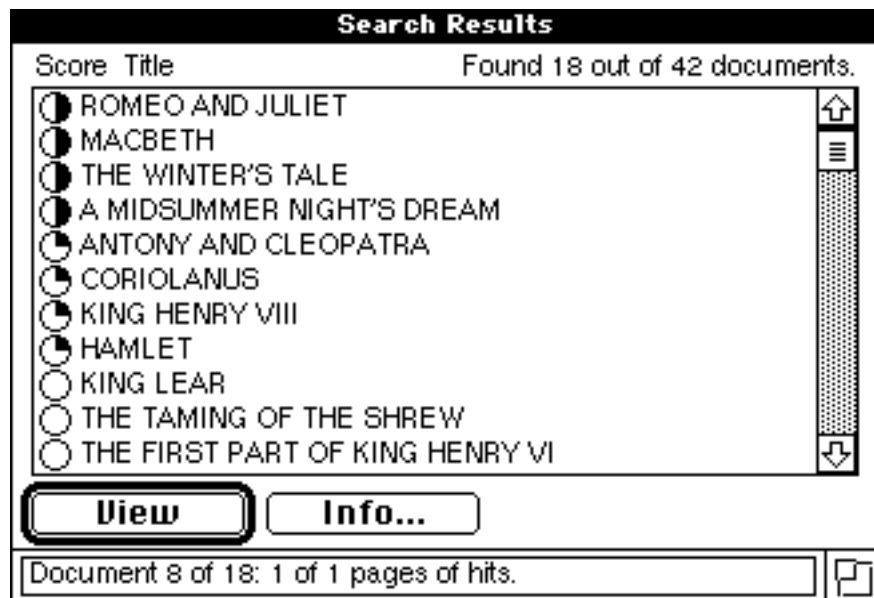


Keeping the Search Results window open

By default, the Search Results window closes when you view a document returned from a search. You can, however, keep the Search Results window open while viewing search results by clearing the Hide on View option in the Acrobat Search Preferences dialog box. Choose Preferences > Search to display the Search Preferences dialog box.








When you keep the Search Results window visible while viewing search results, the Search Results window reports how many documents were found, how many pages in the current document contain a search term, and which page in the current document is being displayed.



Relevance ranking (score)

Acrobat Exchange assigns a relevance ranking to every document returned from a search. A document's relevance ranking indicates how likely it is that the document contains the information for which you are searching.

Acrobat Search uses five icons to indicate a document's relevance ranking:

-  A full circle indicates a very high relevance ranking; the document is very likely to contain relevant information.
-  A three-quarter circle indicates a high relevance ranking; the document is likely to contain relevant information.
-  A half circle indicates a medium relevance ranking; the document probably contains relevant information.
-  A one-quarter circle indicates a low relevance ranking; the document might contain relevant information.
-  An empty circle indicates a very low relevance ranking; the document is unlikely to contain relevant information.



The method used to determine a document's relevance ranking depends on the kind of search performed. With a single search term, for example, the relevance ranking indicates how frequently the term appears in the document. When two search terms are separated by an OR operator, however, documents that contain both terms have a relevance ranking higher than documents that contain just one of the terms. Similarly, when you use the Proximity search option, the closer search terms are within a document, the higher the relevance ranking for the document.

Another factor that contributes to a document's relevance ranking is the density of search terms relative to other terms in the document. The higher proportion of search terms in a document, the higher the document is ranked.

Search preferences

You can use the Acrobat Search Preferences dialog box to

- Control whether the Search window closes when you perform a search
- Control the size and contents of the Search window. (You can show or hide the Document Info fields, the document date fields, and the search options.)
- Control whether the Search Results window closes when you view a document returned from a search
- Control the number of found documents listed in the Results window, and the order in which they are listed
- Control whether all search terms on a page are highlighted, whether terms on a page are highlighted one at a time, or whether no terms are highlighted
- Control whether Macintosh file server volumes that contain indexes you are using are automatically mounted when you start Acrobat Search



See [Query preferences](#) for details about the preference settings that control the Acrobat Search window. See [Results preferences](#) for details about the preference settings that control the Search Results window. See [Indexes preference](#) for details about the index file server automount setting.

Query preferences

The Query preferences control the size, contents, and behavior of the Acrobat Search window.

Query	
<input checked="" type="checkbox"/> Show Fields	<input checked="" type="checkbox"/> Show Date
<input checked="" type="checkbox"/> Show Options	
<input checked="" type="checkbox"/> Hide on Search	

- **Show Fields** displays the Document Info fields with the Search window.
- **Show Options** displays the search options with the Search window.
- **Show Date** displays the Date Info selection options with the Search window. The Date Info options let you limit the results of a search to documents that were created or modified during a specific time period.
- **Hide on Search** closes the Search window when you perform a search; clear this option to keep the Search window displayed while you view search results.

Results preferences

The Search Results preferences control the behavior of the [Search Results window](#).

Results	
Sort By:	Score ▼
Show Top:	100 Documents
<input type="checkbox"/> Hide on view	
Highlight	
Display:	By Page ▼

▪ **Sort By** controls the order in which documents are listed in the Search Results window. By default, documents are sorted by score, which lists them in the order of their [relevance ranking](#). You can also sort found documents by creation date, modification date, or by one of the Document Info field values, such as Title or Author. When you sort found documents by Document Info field values, they are listed alphabetically by field values.



When you sort by Created or Modified date values, documents are sorted by date in descending order. The most recent dates are listed first.

Documents with empty fields are listed before documents with field values.

When documents are sorted by score, documents with the same score are listed alphabetically by title (or filename if they have no title).

When documents are sorted by any value other than score, documents with the same sort value are sorted by score.

- **Show Top __ Documents** defines the maximum number of documents you want Acrobat Search to return from a search. Enter any value between 1 and 1000.

- **Hide on View** closes the Search Results window when you view a document returned from a search; clear this option to keep the Search Results window visible while you view search results.



- **Highlight Display** controls how Acrobat Search highlights found search terms and how the Search Next and Search Previous buttons work.
- **By Page** highlights all the search terms on a page. Search Next and Search Previous display the next or previous page with found terms.
- **By Word** highlights found search terms one at a time. Search Next and Search Previous highlight the next or previous found term.
- **No Highlighting** does not highlight search terms. Search Next and Search Previous display the next or previous page that contain found terms.

Indexes preference (for Macintosh only)

The Indexes preference controls whether network file servers that contain currently selected indexes are automatically mounted when you start Acrobat Search.

Indexes

☒ Automount servers

Select Automount Servers to connect automatically to file servers that contain selected indexes. When Automount Servers is not selected, you must manually mount servers that contain indexes before you can use the indexes.

About Acrobat indexes

The Acrobat Catalog program creates [full-text indexes](#) for collections of PDF documents. Acrobat Search uses these indexes to locate words quickly in documents that make up indexed collections.

Words and terms included in an index

By default, an Acrobat index lists every word, number, and alphanumeric term that appears in every document in the indexed document collection. An *alphanumeric term* is a sequence of letters and numbers. See [How terms are indexed](#) for details.

Stopwords

To reduce the size of an index, an index publisher can exclude stopwords from an index. Stopwords are not indexed. Usually, stopwords are common words that do not serve to identify topics or subjects. Carefully chosen stopwords can reduce the size of an index without reducing its usefulness.



Typical stopwords include

- Articles such as *the* and *a*
- Prepositions such as *for*, *by*, and *of*
- Conjunctions such as *or* and *and*

Each index can be built with a different stopword list.

Because they are not placed into the index, you cannot find stopwords with Acrobat Search. Also, you cannot find a phrase that contains a stopword.

See [Typical stopword list](#) for a list of common stopwords.

Numbers

Another way index publishers can reduce the size of an index is to exclude numbers from an index. See [How Acrobat Catalog excludes numbers](#) for a description of how the Catalog program identifies numbers.

Full-text indexes

A *full-text index* is an alphabetized list of all the words and alphanumeric terms that occur in a collection of documents. For each word and alphanumeric term in the document collection, a full-text index lists the documents and pages where the word or term appears. Given a full-text index, search software can quickly locate all the occurrences of a search term without opening and searching the documents. The following table shows part of a full-text index for Shakespeare's plays.

Term	Document (Play)	Pages
abed	<i>All's Well That Ends Well</i>	150
	<i>As You Like It</i>	36
	<i>Cymbeline</i>	86
	<i>Macbeth</i>	35
	<i>Othello</i>	82
	<i>Romeo and Juliet</i>	111, 142
	<i>Twelfth Night</i>	38



Term	Document (Play)	Pages
abel	First Part of <i>King Henry VI</i>	25
Abel's	<i>King Richard II</i>	9
Abergavenny	<i>Henry VIII</i>	2, 6, 9, 10, 11, 19, 28
abet	<i>King Richard II</i>	71
abetting	<i>Comedy of Errors</i>	33

Note: *Indexes distinguish between uppercase and lowercase letters only when publishers build them to support the Match Case option. Otherwise, all index terms are spelled with lowercase letters.*

See [How terms are indexed](#) for a description of how the Acrobat Catalog program recognizes words and terms.

Troubleshooting searches

This topic provides advice for solving problems you might encounter when using the Search command. Solutions are described under the error message you will see.

The index is unavailable

Indexes might be unavailable for one or more of the following reasons:

- The connection to the network server containing the index has been lost.
- The index is being purged and rebuilt; this maintenance operation takes time but can significantly reduce the size of an index.
- The index has been moved to a new location.
- The index has been deleted.

Contact your network administrator if you suspect you have lost your connection to a server.



Contact the person responsible for the index if you suspect the index is being purged and rebuilt, or if you suspect that it has been moved or deleted.

Highlights will not be displayed

Acrobat Exchange displays this message when it tries to open a PDF document that has changed since the index was built. The change may not have altered the locations of the words on the page. Adding a note to a PDF document or security settings, for example, causes Acrobat Exchange to display this message.

If the change to the file did alter the locations of words, the search term highlights will be incorrect. For example, if a page was deleted, highlights will indicate the wrong words.

If you think the change to the PDF document did not alter the locations of words in the document, or if you think you will be able to tell whether the highlights are correct, click the Highlight Anyway button to close the message box and view the document.



Note: Index creators can suppress this message by selecting the *Optimize for CD-ROM* option in the Adobe Acrobat Catalog Options dialog box. See *Optimize for CD-ROM* option in the Adobe Acrobat Catalog Online Guide.

No documents were found that matched your query

Acrobat Exchange displays this message when no documents in the currently selected indexes meet the criteria you specify with a search query. If you get this message, try these steps:

- Make sure you have selected the indexes that contain the documents with the information you seek.
- Make sure you are not using Document Info or Date Info field values—or search options from the previous query by mistake.
- Make sure you are not searching for a stopword in an index that has stopwords.
- Make sure you are not searching for a number in an index from which numbers have been excluded.
- If you are using an operator such as AND or NOT in a phrase, make sure the phrase is enclosed in quotation marks (“ ”).



Out of file handles

You are running too many programs or you have too many windows open. Close some windows, and try the query again. If you are running two or more programs, quit all programs except Acrobat Exchange and retry the query.

Not enough memory (Macintosh)

If you get a message saying you do not have enough memory for Acrobat Exchange to find the documents that meet your search criteria, you can try increasing the memory available to the Acrobat Exchange program.

- 1** If Acrobat Exchange is running, quit the application.
- 2** From the Finder, click to select the Exchange program icon.
- 3** Choose Get Info from the File menu. The Get Info dialog box appears.
- 4** In the Memory Requirements box, increase the Minimum size value. For example, you might increase the Minimum size value to 2500 or 3000. (The maximum amount of memory available for the application is limited by the amount of memory installed in your Macintosh.)



5 Click the close box in the upper left corner of the Get Info dialog box.

6 Start Acrobat Exchange. If a message appears, telling you that there is not enough memory to run the program, decrease the Minimum size value in the Acrobat Exchange Get Info box.

Tools menu commands

In the following command descriptions, the number to the right of the tool indicates the variable shortcut key for selecting the tool. To select the tool, press Control+Shift+this number (Windows) or Command+Option+this number (Macintosh).

Hand (1) selects the hand tool. To use the hand tool, drag the document in the direction you want it to move.

Zoom In (2) selects the zoom-in tool. Click the tool to double the magnification of the page view. See [Magnifying the page view](#) for more information.

Zoom Out (3) selects the zoom-out tool. Click the tool to halve the current magnification of the page view. See [Magnifying the page view](#) for more information.

Select Text (4) selects the text selection tool. Drag to select text. Use the Copy command to copy the selected text to the Clipboard. See [Copying text to the Clipboard](#) for more information.



Select Graphics (5) selects the graphics selection tool. Drag to select the image you want to copy. Use the Copy command to copy the bitmap image to the Clipboard.

See [Copying graphics to the Clipboard](#) for more information.

Note (6) selects the note tool. Drag the tool to draw a note window. See [Using notes](#) for more information.

Link (7) selects the link tool. Drag the tool to draw a link rectangle; then move to the page to which you want to link the button, and click OK. See [Using links](#) for more information.

Article (8) selects the article tool. Drag the tool to draw an article box. Release the mouse button to close the article. Continue drawing as many boxes as are necessary to guide the viewer through the article. See [Creating articles](#) for more information.

Find (Ctrl/Command+F) displays the Find dialog box, which you can use to find part of a word, a complete word, or multiple words in a document. See [Finding words](#) for more information.

Find Again [Command+G(M); F3(W)] performs the same operation as the Find button in the Find dialog box: the next occurrence of the word is displayed.



Find Next Note (Ctrl/Command+T) moves to the next page containing a note. The command does not display or open the note.

Summarize Notes (Ctrl/Command+Shift+T) creates a PDF file that contains the text of all the notes in a document. See [Using notes](#) for more information.

The Search tools buttons enable you to search libraries of PDF documents that have been indexed by using Acrobat Catalog.

- **Search/Query** (Ctrl/Command+Shift+F) displays the Search dialog box.

- **Search/Indexes** (Ctrl/Command+Shift+X) displays the Index Selection dialog box.

- **Search/Results** (Ctrl/Command+Shift+J) displays the Search Results dialog box.

- **Search/Word Assistance** (Ctrl/Command+Shift+W) displays the Word Assistant dialog box.

- **Search/Previous Document** (Ctrl/Command+Shift+Y) displays the last occurrence of a search term in the document that precedes the current document in the Search Results list.



- **Search/Previous** (Ctrl/Command+Y) displays the previous occurrence of a search term in the current document. If there are no more occurrences in the current document, the last occurrence of a search term in the previous document is displayed. Search Previous displays documents in the order they are listed in the Search Results dialog box.
- **Search/Next** (Ctrl/Command+U) displays the next occurrence of the search term. When the last occurrence of a word in a document is displayed, Search Next displays the first occurrence in the next document. Search Next displays documents in the order they are listed in the Search Results dialog box.
- **Search/Next Document** (Ctrl/Command+Shift+U) displays the first occurrence of a search term in the document that follows the current document in the Search Results list.



Paging shortcuts

Tool or key	Plus	Result
Right Arrow	Shift	Scrolls page to the right
Left Arrow	Shift	Scrolls page to the left
Up Arrow	Shift	Scrolls page up
Down Arrow	Shift	Scrolls page down
Ctrl/Command	4	Last page
End key		Last page
Escape key or Command+Period (Macintosh)		Exit full-screen display

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Adobe Acrobat Exchange 2.1 Online Guide

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