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PROCEEDINGS OF THE
**31st IEEE CONFERENCE ON
DECISION AND CONTROL**



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**DECEMBER 16-18, 1992
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TUCSON, ARIZONA, USA**



**IEEE
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Systems
Society**

VOLUME 4 OF 4

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THE 31ST IEEE CONFERENCE ON DECISION AND CONTROL

DECEMBER 16 - 18, 1992

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Courtesy of the Metropolitan Tucson Convention and Visitors Bureau.

FOREWORD

Welcome to this major annual meeting of the IEEE Control Systems Society – 31st IEEE Conference on Decision and Control (CDC) – which continues to grow, as evidenced from the record number of submissions received this year. The technical program consists of 117 contributed and invited sessions, comprising over 900 papers by over 1400 authors. It was again prepared in cooperation with the Society for Industrial and Applied Mathematics (SIAM) and the Operations Research Society of America (ORSA), under the direction of the Program Chairman, Sergio Verdú. In addition to the contributed and invited sessions, the Conference features this year three plenary sessions, one on each day: On Wednesday morning, John N. Tsitsiklis will present a lecture with the title “*Complexity-Theoretic Aspects of Problems in Control Theory*.” On Thursday morning, Pravin Varaiya will present the second plenary, entitled “*Smart Cars on Smart Roads: Design and Evaluation*”. On late Friday morning, Brian D. O. Anderson, the recipient of this year’s Bode Prize, will deliver the Bode Lecture entitled, “*Controller Design: Getting from Theory to Practice*.”

This year, the CDC is preceded by five tutorial workshops, covering a broad spectrum of topics of current and emerging interest to the control systems community. They are all one-day workshops, distributed over two days – three on Monday, and two on Tuesday. Those planned for Monday are entitled, “*Intelligent Control with Applications*”, “*Modeling and Scheduling in Semiconductor Fabrication*”, and “*Identification and Robust Control Interplay*”; the two on Tuesday are “*Robust Control for State Space Systems*”, and “*An Introduction to Control of Smart Structures*”.

Several exhibits are planned for the entire duration of the Conference, which will include demonstrations of software for control system design and books from several publishers. The Awards Ceremonies, to be conducted during the Thursday’s dinner banquet, will feature the presentation of several IEEE and CSS awards, and Fellow certificates.

As the number of submissions and proportionately the number of participants grew over the years, organizing the CDC has become a major undertaking, on both the administrative and technical sides. Our community is fortunate to have individuals who can devote their time and efforts freely toward successful completion of such tasks. Members of the Operating and Program Committees (whose names can be found on the facing page), the Editorial Board of the IEEE Transactions on Automatic Control, and hundreds of anonymous reviewers deserve our gratitude for many hours they have spent to ensure that we have a smooth running conference of top technical quality. Special recognitions go to André Tits, Vice Chair for Program, who did much more than his share of work, in the assembling of the Technical Program, and to Rodolfo Milito, Publications Chairman, who ably coped with the myriad of details required to produce the Advance and Final Programs, as well as this four-volume Proceedings. Special thanks also go to Mrs. Francie Bridges and Ms. Dixie Murphy, of the University of Illinois, for their efficient secretarial services during all phases of the organization of this CDC.

The Operating Committee has worked hard to create an environment for the participants to get the most benefit out of the Conference. We hope that these efforts were well worth it and that *you*, as a participant, will value this meeting as a memorable event, both scientifically and socially. Thank *you* for your participation in this year’s CDC, and your contribution toward its success.

Tamer Başar
General Chairman

IEEE CONFERENCE ON DECISION AND CONTROL PAST AND PRESENT

Following the tradition of last year's CDC, we are providing here a complete list of past conferences in this series, with titles, chairs and locations.¹ The CDC grew out of the former Symposium on Adaptive Processes, to become the premier conference in the field that it is today. At first it was associated with the Joint Automatic Control Conference (JACC - now the ACC) and then the National Electronics Conference (NEC). In the following listing GC denotes General Chair, PC stands for Program Chair, and SC is Symposium Chair. The proceedings of all past conferences may be perused at the IEEE Library, 345 47th Street, New York, NY 10017.

DISCRETE ADAPTIVE PROCESSES - SYMPOSIUM AND PANEL DISCUSSION (AIEE); part of 3rd JACC

GC: J. Sklansky
New York University, New York City, NY; 29 June 1962

SYMPOSIUM ON ADAPTIVE PROCESSES; part of NEC

GC: L. Kanal
McCormick Place, Chicago, IL; 28-29 October 1963

SYMPOSIUM ON ADAPTIVE PROCESSES; part of NEC

GC: F. J. Mullin
McCormick Place, Chicago, IL; 19-21 October 1964

SYMPOSIUM ON ADAPTIVE PROCESSES; part of NEC

GC: E. C. Jones, Jr., PC: G. Brown
McCormick Place, Chicago, IL; 25-27 October 1965

SYMPOSIUM ON ADAPTIVE PROCESSES; part of NEC

GC: F. N. Bailey, PC: J. C. Hancock
McCormick Place, Chicago, IL; 3-5 October 1966

SYMPOSIUM ON ADAPTIVE PROCESSES; part of NEC

GC: F. M. Waltz, PC: P. E. Mayes
International Amphitheater, Chicago, IL; 23-25 October 1967

IEEE SYMPOSIUM ON ADAPTIVE PROCESSES

PC: J. M. Mendel
UCLA, Los Angeles, CA; 16-18 December 1968

IEEE SYMPOSIUM ON ADAPTIVE PROCESSES

GC: J. B. Lewis, PC: G. J. McMurty
Pennsylvania State University, PA; 17-19 November 1969

1970 IEEE SYMPOSIUM ON ADAPTIVE PROCESSES (9th) DECISION AND CONTROL

PC: D. G. Lainiotis
University of Texas, Austin, TX; 7-9 December 1970

¹This information was compiled last year by Panos Antsaklis with help from Jack Rugh and Len Shaw.

- 1971 IEEE CONFERENCE ON DECISION AND CONTROL**
including the 10th SYMPOSIUM ON ADAPTIVE PROCESSES
GC: J. T. Tou, PC: S. K. Mitter, SC: J. M. Mendel
Americana Hotel, Miami Beach, FL; 15-17 December 1971
- 1972 IEEE CONFERENCE ON DECISION AND CONTROL**
including the 11th SYMPOSIUM ON ADAPTIVE PROCESSES
GC: J. M. Mendel, PC: Y. C. Ho, SC: G. N. Saridis
Fontainebleau Motor Hotel, New Orleans, LA; 13-15 December 1972
- 1973 IEEE CONFERENCE ON DECISION AND CONTROL**
including the 12th SYMPOSIUM ON ADAPTIVE PROCESSES
GC: J. S. Meditch, PC: D. G. Luenberger, SC: L. A. Gerhardt
Sheraton-Harbor Island Hotel, San Diego, CA; 5-7 December 1973
- 1974 IEEE CONFERENCE ON DECISION AND CONTROL**
including the 13th SYMPOSIUM ON ADAPTIVE PROCESSES
GC: E. Axelband, PC: S. Kahne, SC: D. P. Lindorff
Del Webb's Towne House, Phoenix, AZ; 20-22 November 1974
- 1975 IEEE CONFERENCE ON DECISION AND CONTROL**
including the 14th SYMPOSIUM ON ADAPTIVE PROCESSES
GC: J. B. Cruz, Jr., PC: J. B. Pearson, SC: G. Stein
Hyatt Regency Houston, Houston, TX; 10-12 December 1975
- 1976 IEEE CONFERENCE ON DECISION AND CONTROL**
including the 15th SYMPOSIUM ON ADAPTIVE PROCESSES
GC: M. Athans, PC: E. R. Barnes, SC: T. Pavlidis
Sheraton-Sand Key Hotel, Clearwater, FL; 1-3 December 1976
- 1977 IEEE CONFERENCE ON DECISION AND CONTROL**
including the 16th SYMPOSIUM ON ADAPTIVE PROCESSES
GC: K. S. Fu, PC: H. Sorenson, SC: T. Pavlidis
Fairmont Hotel, New Orleans, LA; 7-9 December 1977
- 1978 IEEE CONFERENCE ON DECISION AND CONTROL**
including the 17th SYMPOSIUM ON ADAPTIVE PROCESSES
GC: Robert E. Larson, PC: Alan S. Willsky, SC: Jerry M. Mendel
Islandia Hyatt House Hotel, San Diego, CA; 10-12 January 1979
- 18th IEEE CONFERENCE ON DECISION AND CONTROL**
including the SYMPOSIUM ON ADAPTIVE PROCESSES
GC: Stephan Kahne, PC: Alexander H. Levis, SC: Yaakov Bar-Shalom
Galt Ocean Mile Hotel, Ft. Lauderdale, FL; 12-14 December 1979
- 19th IEEE CONFERENCE ON DECISION AND CONTROL**
including the SYMPOSIUM ON ADAPTIVE PROCESSES
GC: Pierre R. Belanger, PC: David L. Kleinman, SC: Richard V. Monopoli
The Regent Hotel, Albuquerque, NM; 10-12 December 1980
- 20th IEEE CONFERENCE ON DECISION AND CONTROL**
including the SYMPOSIUM ON ADAPTIVE PROCESSES
GC: William R. Perkins, PC: Abraham H. Haddad, SC: K. S. Narendra
Vacation Village Hotel, San Diego, CA; 16-18 December 1981

- 21st IEEE CONFERENCE ON DECISION AND CONTROL**
GC: Alexander H. Levis, PC: William S. Levine
Holiday Inn - International Drive, Orlando, FL; 8-10 December 1982
- 22nd IEEE CONFERENCE ON DECISION AND CONTROL**
GC: James L. Melsa, PC: Steven I. Marcus
Marriott Hotel, San Antonio, TX; 14-16 December 1983
- 23rd IEEE CONFERENCE ON DECISION AND CONTROL**
GC: Abraham H. Haddad, PC: Michael P. Polis
Las Vegas Hilton, Las Vegas, NV; 12-14 December 1984
- 24th IEEE CONFERENCE ON DECISION AND CONTROL**
GC: Gene F. Franklin, PC: Anthony N. Michel
Bonaventure Hotel & Spa, Ft. Lauderdale, FL; 11-13 December 1985
- 25th IEEE CONFERENCE ON DECISION AND CONTROL**
GC: Anthony Ephremides, co-GC: Spyros Tzafestas, PC: H. Vincent Poor
Atheneum Intercontinental Hotel, Athens, GREECE; 10-12 December 1986
- 26th IEEE CONFERENCE ON DECISION AND CONTROL**
GC: William S. Levine, PC: John Baillieul
Westin Century-Plaza Hotel, Los Angeles, CA; 9-11 December 1987
- 27th IEEE CONFERENCE ON DECISION AND CONTROL**
GC: Michael P. Polis, PC: William E. Schmitendorf
Hyatt Regency Austin on Town Lake, Austin, TX; 7-9 December 1988
- 28th IEEE CONFERENCE ON DECISION AND CONTROL**
GC: Leonard Shaw, PC: Tamer Başar
Hyatt Regency Tampa Hotel, Tampa, FL; 13-15 December 1989
- 29th IEEE CONFERENCE ON DECISION AND CONTROL**
GC: Charles J. Herget, PC: Raymond A. DeCarlo
Hilton Hawaiian Village, Honolulu, HI; 5-7 December 1990
- 30th IEEE CONFERENCE ON DECISION AND CONTROL**
GC: Derek P. Atherton, PC: Panos J. Antsaklis
Metropole Hotel, Brighton, ENGLAND; 11-13 December 1991
- 31st IEEE CONFERENCE ON DECISION AND CONTROL**
GC: Tamer Başar, PC: Sergio Verdú
Westin La Paloma, Tucson, AZ; 16-18 December 1992

THE 31st IEEE CONFERENCE ON DECISION AND CONTROL

PLENARY & BODE LECTURER BIOGRAPHIES



PLENARY 1 : John N. Tsitsiklis was born in Thessaloniki, Greece in 1958. He received the B.S. degree in Mathematics (1980), and the B.S. (1980), M.S. (1981) and Ph.D. (1984) degrees in Electrical Engineering, all from the Massachusetts Institute of Technology (*M.I.T.*), Cambridge, Massachusetts. During the academic year 1983-84, he was an acting assistant professor of Electrical Engineering at Stanford University, Stanford, California. Since 1984, he has been with the Department of Electrical Engineering and Computer Science at *M.I.T.*, where he is currently an associate professor. His research interests are in the areas of systems and control theory, parallel and distributed computation, and operations research. Dr. Tsitsiklis is a coauthor (with D. Bertsekas) of *Parallel and Distributed Computation: Numerical Methods* (1989). He has been a recipient of an IBM Faculty Development Award (1983), and NSF Presidential Young Investigator Award (1986), an Outstanding Paper Award by the IEEE Control Systems Society (for a paper coauthored with M. Athans), and of the Edgerton Faculty Achievement Award by *M.I.T.* (1989). He is an associate editor of *Automatica* and *Applied Mathematics Letters*, and has been an associate editor of the *IEEE Transactions on Automatic Control*.



PLENARY 2 : Pravin Varaiya is a professor of Electrical Engineering & Computer Sciences at the University of California, Berkeley. He received his Ph.D. in Electrical Engineering from the University of California at Berkeley. He is the author, with P. R. Kumar, of *Stochastic Systems: Estimation, Identification, and Adaptive Control*, Prentice-Hall, 1986 and editor, with A. Kurzhanski, of *Discrete Event Systems. Models and Applications*, Lecture Notes in Information Sciences, vol. 103, Springer, 1988. His area of research and teaching are in stochastic systems, communication networks, power systems and urban economics.



BODE LECTURE : Brian D.O. Anderson was born in Sydney, Australia, and received his undergraduate education at the University of Sydney, with majors in mathematics and electrical engineering. He subsequently obtained a Ph.D. degree in electrical engineering from Stanford University. Following completion of his education, he worked in industry in Silicon Valley and served as a faculty member in the department of electrical engineering at Stanford. In 1967, he joined the electrical engineering department at the University of Newcastle, Australia, where he remained until the end of 1981. At that time he became professor of Systems Engineering at the Australian National University. His research interests are in control engineering and signal processing, and he has co-authored a number of books in these fields, as well as research papers. He is a Fellow of the Royal Society, the Australian Academy of Science, Australian Academy of Technological Sciences and Engineering, and the Institute of Electrical and Electronic Engineers, and an Honorary Fellow of the Institute of Engineers, Australia. He holds a doctorate (*honoris causa*) from the Catholic University of Louvain, Belgium. He has served or is serving on government committees and councils including the Prime Minister's Science and Engineering Council, and is also a company board member. He is serving a term as President of the International Federation of Automatic Control from 1990 to 1993.

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WA 10:00 to 12:30	Neural Networks in Control	Identification I	Nonlinear Systems Theory	Numerical Methods	Linear Multivariable Control	Linear Systems: Observers & Control	Robust Control I	Adaptive Control Nonlinear Systems	Robotics: Flexible Manipulators & Path Planning	Robust Stabilization	Stability of Distributed Parameter Systems	Scheduling of Flexible Manufacturing Systems	Transfer Function & Matrix Fraction Design
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