Newsletter of the IEEE Robotics & Automation Society

# IEEE ROBOTICS AND AUTOMATION

Volume 5 Number 1 Winter 1991

*Editor: Dr. Michael B. Leahy, Jr.*
Air Force Institute of Technology
AFIT/ENG, WPAFB, Ohio 45433
513-255-9629 or
mleahy@blackbird.afit.af.mil
*Associate Editors*
Prof. A. C. Kak, Purdue University
Dr. Thomas C. Henderson,
University of Utah
Dr. John Baillieul, Boston University

*Managing Editor*: Ms. Rosalyn Snyder
3603 Octavia St.
Raleigh, NC 27606
(919) 851-1433 or
roz%hobie@mcnc.org

*Society President*: Mr. Norman C. Caplan,
National Science Foundation
*1991 Conference Chair*: Prof. T. C. Hsia,
University of California, Davis

## *Advance Announcement and Registration Information Inside! 1991 IEEE International Conference on Robotics and Automation*



THE INSTITUTE OF ELECTRICAL
AND ELECTRONICS ENGINEERS, INC.
IEEE

# MEMBERSHIP APPLICATION
# IEEE ROBOTICS AND AUTOMATION SOCIETY

1. I am a member of the IEEE. My member number is : _____
Please enroll me in the Robotics and Automation Society. **$15.00**

2. I am not an IEEE member. I wish to join the IEEE and enroll in the Robotics and Automation Society.

| | |
|---|---|
| United States | **$98.00** |
| Canada | **$90.00** |
| Europe, Africa, Middle East | **$89.00** |
| Latin America | **$82.00** |
| Asia & Pacific | **$80.00** |
| Full-time students: | |
| United States or Canada | **$29.50** |
| All others | **$22.50** |

3. I am not a member of the IEEE, but I am a member of the following other professional society _____. I am applying for affiliate membership in the Robotics & Automation Society. **$47.00**

4. In addition to one of the above options, I wish to subscribe to the IEEE Transactions on Neural Networks. **$10.00**

Total amount enclosed: _____

[ ] Check enclosed. Remit in U.S. dollars drawn on a U.S. bank. Make check payable to IEEE. Payments made in local currency must include an additional 2% currency exchange fee and a $15.00 U.S. bank fee.

[ ] Charge to my credit card:
[ ] Visa [ ] American Express
[ ] Mastercard [ ] Diners Club

Credit Card Number: _____

Expiration date: _____

Signature: _____

Date: _____

First name: _____

Middle initial: _____

Last name: _____

Street address: _____

City: _____

State/Country: _____

Postal Code: _____

Applicants for IEEE membership please complete the following information:

Were you ever a member of IEEE ? _____

If yes, please furnish grade and membership number _____

Years in professional practice: _____
Date of birth: _____

[ ] Male [ ] Female

Education (Highest technical degree completed):

_____

Date: _____

University: _____

Endorsement by one IEEE member who knows you professionally

Name: _____

IEEE member number : _____

Signature: _____

**Mail to:** IEEE, Membership Services, P.O.Box 1331, Piscataway, NJ 08855-1331, U.S.A.

THE INSTITUTE OF ELECTRICAL
AND ELECTRONICS ENGINEERS, INC.

IEEE

# President's Message

*Norman Caplan*
*National Science Foundation*

Due to the time delays involved with the publishing and distribution of the Newsletter I am writing this message in December, prior to actually assuming the position of Society President. More accurately, the title of this message should be the President-Elect's Message since I'm now in the process of learning the duties and responsibilities of the office. These duties involve the administration of the Society, as well as liaison interaction, and participation with the parent Institute of Electrical and Electronic Engineers.

Having attended the Technical Advisory Board (TAB) meeting recently held in San Diego, I have developed a greater appreciation of the effort required to make the IEEE, and the individual Societies function in an efficient and professional manner. One week of meetings in San Diego, with a minimum of leisure time, gave me a new appreciation of the work being done by the volunteers who are the backbone of the success of IEEE.

This brings me to the Robotics and Automation Society and the volunteers who have worked so hard to make our society the success that it is. I would like to thank everyone whose efforts helped build this Society from a concept to reality in a very short time span. Specific thanks should go to Art Sanderson, (who put in a two year term as President) along with the team of Vice Presidents and AdCom. members. The Society would be far less effective and successful without the contribution of these people and others who volunteer their time and energy. I can't finish this paragraph without mentioning and offering a special thank you to George Saridis, the Founding President of the Society. Without George's vision and hard work we would be far less than we are today.

The Society that I have become President of is a young organization that has grown very rapidly over the past few years. One reason for this growth is the technical scope of the Society's interests. For those of us who have been encouraging this technical area over the last ten to twenty years, it is indeed gratifying to see rapid growth and the increasing sophistication of the technical community. For many years we worked to convince our colleagues that robotics went beyond gadgetering and represented a technical specialty. Now we are entering a more advanced phase of the maturing process, and heading in new directions that I hope to pursue during the next year.

The IEEE Robotics and Automation Society is a professional, technical organization whose primary function is associated with technical activities. However, the term "professional" must also be considered in a broad context. As members of the Society we are professionals who have much to offer our specialized field and also the rest of society.

The economics of the United States and the world are at a critical point in history, as a result of over a century of change, initiated by the industrial revolution. Robotics and

Automation technology represents the most advanced stage of this process which is capable of benefiting millions of people. I believe that our society members provide an important resource for improved education, international understanding, societal outreach, and technical consultations. I believe that the R&A Society has the ability and the obligation to make a major contribution.

I hope that in the coming year we can start a meaningful dialogue about these subjects. In the meantime I welcome your opinions and thoughts about the Society and the directions that we should be moving toward.

# FROM THE EDITOR

*Michael B. Leahy*
*Air Force Institute of Technology*

Welcome to the winter issue of the Society Newsletter. Many thanks to those of you who responded to my request for email addresses and suggestions. Keep those suggestions coming, remember it is your newsletter. In your newsletter this month you will find several new items. First is the Advance Announcement for the 1991 IEEE International Conference on Robotics and Automation to be held April 7-12th in Sacramento California. Having participated in the technical program committee meeting in St. Louis on the 1st of December, I am excited about the ideas that will be presented at the conference. There will also be several tutorials on Monday and workshops on Friday so make your plans now to spend a week with your peers in the capital city of California. The spring issue of the newsletter will contain the full final advanced program and should be available in the middle of March.

Inclusion of the announcements and programs is part of the overall objective of improved coverage of conferences. If your conference is sponsored by the Society we can prominently feature your calls for papers. If you had the opportunity to recently attend a conference or symposium please consider taking the time to write up a short article about what you found interesting. Few people can attend all the robotics conferences and symposia currently available but many would welcome the chance to benefit from your observations. Two such conference reports are included in this issue.

Along with providing information about society happenings, the newsletter should also be a forum for exchanging ideas. In this issue are letters by two of my associate editors, Avi Kak and Tom Henderson, on some of their thoughts about robotics. If you have some thoughts or opinion to share with the society we have the space to print them.

Starting next issue we will add two new regular features. *On the Move* will provide a convenient way for letting the whole society know that you have changed jobs. To be included just send me your new employer, location, title, phone, fax and email address. The second feature will highlight members who have recently received *Promotions or Awards*. Again just send the pertinent information to Rosalyn Snyder or me.

Also in this issue is a report from the local chapter in the Princeton area. All it takes are twelve members of the society to start a local chapter. A local chapter is a great way to become active in the society and to grow personally and professionally. For more details contact Dr. Harry Stephanou, our vice president for membership.

Finally I would like to issue a call for articles describing experimental facilities. Many of us have worked hard to create an environment that allows state-of-the-art experimental robotics research. In many cases information on that

environment is buried in an article that concentrates on the research contributions achieved from utilization of the equipment. I am offering you the chance to highlight the bolts and bits part of your laboratory. Write up a short description of your set-up. Block diagrams and pictures, especially those in postscript format, are welcome. If you think fellow researchers should emulate your systems tell us why. The goal is to get a condensed picture of the options available to researchers interested in revising existing facilities or creating new ones. The articles will be published in a special section in the fall issue.

Have a safe and happy holiday season. Hope to hear from you in the new year.

*mbl*

# AdCom Notes

The Nominating Committee has nominated the following eight candidates to stand for AdCom election (for 6 vacant positions) in January 1991:

- George A. Bekey
- T. C. Steve Hsia
- Toshio Fukuda
- A. C. Kak
- George Harhalakis
- Robert B. Kelley
- John M. Hollerbach
- Antti J. Koivo

Members should receive their ballots shortly if they have not done so already.

The 1990 IEEE International Conference on Robotics and Automation had a record number of conference attendees as well as paper submissions.

Congratulations to Professors R. A. Volz and A. J. Koivo and their organizing committee for a job well done.

The 1992 Conference will be held in Nice, France on May 10-15, 1992. This will be the first time that our annual conference will be held in Europe.

The General Chairman is Professor Giuseppe Menga and the Program Chairman is Dr. Georges Giralt.

Professor Wayne Book has proposed to host the 1993 conference in Atlanta, Georgia. The AdCom has approved the proposal subject to reviewing the budget at the next AdCom meeting.

After leading the Society for the past two years as the Society President, Professor Art Sanderson will move on to become Chairman of the Nominating Committee effective January 1, 1991. He will have the important task of nominating able persons to serve the Society. If you are interested in participating more actively in the affairs of the Society, please send Professor Sanderson your updated short biography, resume and your areas of expertise.

Professor T. J. Tarn, who has ably served as Vice-President of Technical Affairs for the past two years, was elected President-Elect 1991 at the April AdCom meeting and will become Society President on January 1, 1992.

The new year will also signify the termination of my tenure as the Society Secretary for the past three years.

President Norm Caplan has appointed Professor David E. Orin of the Ohio State University to serve the Society as the Secretary.

I will continue to serve the Society as Vice-President of Technical Affairs effective January 1, 1991.

The Society also thanks Professor Y. C. Ho for nominating so many able persons to serve the Society as Executive Officers and Administrative Committee members.

The Society also would like to thank Professor Wesley Snyder, past Newsletter Editor, for his diligent work and tireless efforts for getting the Society's Newsletter up on its feet. The Newsletter has gradually become an important publication of the Society.

*George S.G. Lee*
*Purdue University*
*R&A Society Secretary*

# Chapter News:

***Princeton Section***

On October 22 the IEEE Robotics and Automation Society Princeton Section, together with the Computer Aids for Industrial Productivity (CAIP) Center at Rutgers University presented a joint seminar entitled "SAM: An Intelligent Perceptive Natural Language Understanding Robot". The speaker was Dr. Michael K. Brown, from the Robotics Principles Research Department at Bell Laboratories, Murray Hill, New Jersey. The speech-activated manipulator is commanded by human voice and currently understands about 15 septillion naturally spoken English sentences.

SAM uses several sensors in a cooperative manner and reasons using a robotic expert system with over 100 rules. The talk was illustrated by video demonstrations. The large number of questions that followed showed the great interest towards this novel man-machine intelligent system.

*Grigore C. Burdea*
*Rutgers University*

# Awards and Honors

***IEEE Fellows Named***

Congratulations to the following members of the Robotics and Automation Society who have recently been elected as new Fellows of the IEEE.

They are:

- **Tien Chang (Steve) Hsia**, University of California, Davis
- **Tosiyasu Laurence Kunii**, University of Tokyo
- **Ramakant Nevatia**, University of Southern California, Los Angeles, Institute for Robotics and Intelligent Systems)
- **Arthur C. Sanderson**, Rensselaer Polytechnic Institute, and
- **Saburo Tsuji**, Osaka University

*Crocker Award*

Dr. Mike Leahy (PhD 1986, RPI), was presented with the Gage H. Crocker Award from the Air Force Institute of Technology, AFIT.

The Gage H. Crocker Award is named after the former head of the School of Systems and Logistics and is presented annually to the professor who made the most significant contribution to the AFIT mission from 1 July of the previous year to 30 June.

Selection is based on excellence in teaching, curriculum development, educational innovation, consulting, research, and other achievements which enhance or contribute to maintaining the excellence of AFIT programs.

The award is sponsored by the AFIT Association of Graduates and was presented at the AFIT Fall Banquet on 16 Nov 1990. Congratulations Mike.

**S. H. Murphy, G. N. Saridis**
***This article was inserted without our editor's knowledge. (RGS)***

# New Arrivals

Congratulations to the following individuals who have recently been awarded the Ph.D.

**Weiyue Wang,** Aug. 1990, *Thesis*: "A Coordination Theory for Intelligent Machines" ECSE, RPI. *Current Position:* visiting professor at the Univ. . of Arizona in Tuscon.

**Steve Murphy,** December 1990, Rensselaer Polytechnic Institute. *Thesis:* "Modeling and Simulation of Multiple Manipulators on a Mobile Platform." *Current Position:* Post-doc at CIRSSE.

**Richard Volpe,** September 1990, Carnegie Mellon University. *Thesis:* "Real and Artificial Forces in the Control of Manipulators: Theory and Experiments" *Advisor*: Pradeep K. Khosla. *Now employed by*: Jet Propulsion Laboratory, CalTech, Pasadena, CA.

**Kevin Cleary,** May 1990, University of Texas at Austin. *Thesis:* "Decision Making Software for Redundant Manipulators" *Advisor*: Del Tesar *Current Position*: (3/25/90 - 12/20/90) Postdoctoral Researcher, Mechanical Engineering Laboratory, Tsukuba, Japan

**M. Kemal Ciliz,** September 1990, Syracuse University, ECE Dept., *Thesis:*"Artificial Neural Network Based Control of Nonlinear Systems with Application to Robotic Manipulators" *Advisor:* Can Isik. *Current Address:* Borg Warner Corp., Ithaca, NY

**John T. Feddema,**August 1989. Purdue University, *Thesis:* "Real-time Visual Feedback Control for Hand-Eye Coordinated Robotic Systems". *Advisor:* S. G. Lee and O. R. Mitchell. *Current Address:* Intelligent Machines Principles Division 1411 Sandia National Labs, Albuquerque, New Mexico 87185.

**J. W. Jeon,** May 1990, Purdue University. *Thesis*: "A Generalized Approach for the Control of Constrained Robot Systems."*Advisor:* C. S. G. Lee. *Current address*: Technical Manager Robotics Research and Development Team Production Engineering Division: Samsung Electronics Co. Suwon City, Kyungki-Do, Korea

**Yihchih Tang** December 1990. Purdue University. *Thesis title:* Integrated Sensors in Robotic Assembly Tasks. *Advisor*: C. S. G. Lee) T *Current address:* Department of Computer Science and Engineering College of Engineering and Applied Sciences, Arizona State University, Tempe, AZ 85287

**Bennett Groshong,** May 1991. North Carolina State Unversity. *Thesis Title*: "Eddy Current Image Restoration: Recovering the Imput to a Nonlinear System, Given Noisy Output", *Advisor:*Wesley E. Snyder.

## Newsletter Editorial Policies

We accept news items, surveys, letters, calendar items, book reviews and reports on work in progress. The editor reserves the right to solicit technical reviews and to reject any contribution which is inappropriate for this newsletter.

Brief (less than 3 column inches) Position Available announcements for universities and other nonprofit research institutes will be published gratis. Longer announcements and commercial ads will be published at our standard advertising rates, which are available from the managing editor. Announcements for upcoming conferences, workshops, etc. of interest to our members will be published gratis in our Calendar and Calls for Papers. Large ads for conferences not sponsored by the R&A Society will normally be run as advertisements although those of special interest may be included at the editor's discretion as space is available.

# Call for R&A Nominations for IEEE Fellows

The IEEE Fellows Committee invites any active member of our Society to submit nominations of qualified individuals for the grade of IEEE Fellow. New IEEE Fellow nomination kits should be available upon request to the

Staff Secretary
IEEE Fellow Committee
345 East 47th Street
New York, New York 10017
Telephone (212) 705-7750

In order to assist potential nominators, a copy of the Fellow Committee's Activities and Fellow qualification outline is published below.

***George Saridis***
***Rensselaer Polytechnic Institute***
***R&A Society Awards Chairman***

## IEEE Fellow Committee Activities

The IEEE Bylaws define the Fellow grade as one of unusual distinction in the profession, to be conferred only by invitation of the Board of Directors upon a person of outstanding and extraordinary qualification and experience in IEEE designated fields (including electrical engineering, electronics, computer engineering and computer sciences, and the allied branches of engineering and related arts and sciences), for important individual contributions to one or more of these fields. The candidate shall hold Senior Member grade at the time the nomination is submitted. Normally the candidate shall have been a member in any grade for a period of five years or more preceding January 1 of the year of election; however, the five-year membership requirements may be waived for a Fellow candidate who has been engaged in professional practice (as needed to qualify for Senior Member grade) in a geographical area where, in the judgment of the Board of Directors, it was difficult to become a member previously, as evidenced by the absence of a Section previously and the recent formation of a new section to cover that geographical area. In such case, membership of five years or more in a recognized local electrical, electronics, or computer engineering society may substitute for the five-year IEEE membership requirement when the nomination is submitted within two years after the formation of the new Section.

The Fellow Committee, appointed by the Board of Directors, has the responsibility for making recommendations to the Board of Director for nominees to be conferred the grade of Fellow.

The Fellow Committee acts as a guardian of IEEE Fellow grade standards and works carefully and faithfully to maintain these standards throughout the IEEE. In the performance of its duties, the Committee is concerned with determine whether the applicants meet the requirements of the IEEE Bylaws and its seeks assistance from many sources in adjudicating the nominations.

The Fellow Committee depends upon the *nominator* of a candidate to furnish all of the basic necessary information requested on the nomination form and to point out the unique contributions of the candidate in a concise and succinct statement.

The Fellow Committee depends upon the *Society evaluations* of the technical contributions of the candidates, and their ranking of the candidates.

The Fellow Committee depends upon the *Fellow grade references* to comment on the candidate's specific achievements which they are qualified to judge.

The Fellow Committee will consider brief *letters of endorsement* from IEEE Sections, Chapters and Committees.

In the processing by the Fellow Committee, the candidates dossiers are evaluated on a basis of eight criteria:

- 1) Individual contributions as engineer, scientist, originator, technical leader, or educator.
- 2) Evaluation by an IEEE Society. Note that only **one IEEE** Society evaluation is to be submitted for each candidate. The nominator is responsible for choosing the IEEE Society that best reflects the candidate's field of technical accomplishments.The Society is responsible for identifying potential problems in Society selection and for notifying the IEEE Fellow Committee and the nominator of recommendations for a more appropriate Society for evaluation.
- 3) Tangible and verifiable evidence of technical accomplishment, such as technical publications, patents, reports, or published descriptions of products, facilities, and/or service;
- 4) Opinions of confidential Fellow references who are qualified to judge the work of the candidate.

•5) Service to IEEE and its predecessors, the AIEE and IRE;
•6) Professional engineering service other than the IEEE
•7) Opinions of endorsers
•8) Total Years in the profession

Having considered all of the valuable information supplied from these many sources, a consensus of Committee judgments is reached on the nominees to be recommended to the Board of Directors for elevation to the IEEE Fellow grade, taking into account the maximum number of recommendations permitted by the IEEE Bylaws which can be submitted annually.

During the next few years, greater attention will be given to recognizing the contributions of practitioners. The following summary is intended to encourage the nominations of practitioners in 1991.

## Recognition of Practitioner Contributions

Election to the grade of Fellow is an important element in pursuit of the IEEE objective of recognizing excellence among its members in the advancement of the theory and practice of electrical and electronics engineering.

The IEEE Board of Directors and the Fellow Committee seek to enhance the recognition accorded to the electrical engineering *practitioner* for outstanding technical contributions.

The practitioner is to be distinguished from the academic who teaches the content of the electrical engineering professional and from the theoretician who deals with the basic science underlying electrical engineering practice. The work of the practitioner can be described as product design and applications, and the construction, operation, and evolution into practical use or manufacturing of items or systems.

Part of the difficulty in providing recognition to the outstanding practitioner is that proprietary considerations of the corporation in which he practices his profession sometimes prevent full documentation of this contributions in the open literature. Recognition of the practitioner must be based on the product (which is publicly visible), by assurances from those within his company regarding his individual

# Robotics and Automation Society IEEE Fellows

The following list of members of the Robotics and Automation Society members who are IEEE Fellows is published in order to assist potential nominators in finding Fellow references for their nominees.

J.K. Aggarwal
Suguru Arimoto
A. Avizienis
George S. Axelby
M.P. Bachynski
John S. Baras
Antal K. Bejczy
G.A. Bekey
P.R. Belanger
Shankar P. Bhattacharyya
Sheldon S. Chang
Y-T Chien
J. H. Collins
Charles Concordia
George E. Cook
Franklin S. Cooper
J.B. Cruz, Jr.
C. C. Cutler
D. Dalasta
Edward J. Davison
J. J. Dazzo
Richard C. Dorf
W.C. Duesterhoeft, Jr.
S. Duinker
Mohamed E. El-Hawary
P. Eykhoff
Wolfgang Fichtner
Herbert Freeman
Leonard B. Gardner
Lester A. Gerhardt
Elmer G. Gilbert
R. C. Gonzalez
Graham C. Goodwin
Madan M. Gupta
A. H. Haddad
Ernest L. Hall
Robert Haralick
Fumio Harashima
John R. Hauser
C. C. Herskind
Yu-Chi Ho
R. G. Hoft
Grace M. Hopper
Tien Chang Hsia
M. Jamshidi
Rangasami L. Kashyap
Hidenori Kimura
F.T. Kohli
P.S. Krishnaprasad
Tosiyasu Laurence Kuni
Martin D. Levine
Peter A. Lewis
Ching C. Li
Lennart L. Jung
John C. Lozier
J. Y. Luh
W. A. Malthaner
Mohamed Mansour
Steven I. Marcus
H. T. Marcy
N. H. McClamroch
R. B. McGhee
James D. Meindl
Fumio Minozuma
A. S. Morse
A. S. Mostafa
Akira Nabae
K. S. Narendra
Ramakant Nevatia
R. W. Newcomb
James D. Palmer
Richard P. Paul
Bernard Picinbono
Kennard Pinder
Veljko Redeka
Edward A. E. Rich
C. A. Rosen
Paul Rosenberg
A. Rosenfeld
William B. Rouse
Arthur C. Sanderson
George Saridis
Gustave Shapiro
Thomas B. Sheridan
S. M. Shinners
J. Sklansky
K .C. Smith
R. A. Soderman
Lawrence Stark
Ching Y. Suen
Noboru Takagi
Ikuo Tanaka
Tzyh-Jong Tarn
John A. Tegopoulos
J. S. Thorp
J. T. Tou
SaburoTsuj
Spyridon G. Tzafestas
P. M. van der Grinten
H. B. Voelcker, Jr.
H. J. Woll

role in creating and developing the product (Fellow references that are suitably specific), and by documentation from within the company which confirms, to some small group within the IEEE, that the individual's relation to the product is as cited. Some level of disclosure of the nature of the product and the individual's specific technical contributions embodied in it are necessary to assure the integrity of the selection process; but, with the passage of time, such disclosure is ultimately palatable for most companies.

It is not the intention of this pursuit of enhanced Fellow recognition of practitioners to reduce the standards for recognition of technical contributions. The goal is to accord to those whose contribution is of a proprietary nature and not immediately publishable, and to those whose contribution is the product and its application, the same recognition now available to those who can publish and/or patent their results and the products that stem from them. The standards for associating the product with the individual and his individual technical contribution must be, if anything, more stringent, since the information is not generally available in public documents and errors in attribution and faulty perspective regarding the importance of the contribution must be guarded against.

This message is intended to encourage those who are seeking to nominate outstanding practitioners. Such nominations will be given special attention by the Society Evaluation Committees and by the Fellow Committee. It is strongly urged that those who were discouraged by the previous emphasis on publicly documented individual contribution should proceed to submit practitioner nominations with the assurance that such nominations will be regarded with a positive attitude by the evaluators.

# Email Directory

| *Name* | *Affiliation* | *Email* | *Fax* |
|---|---|---|---|
| Barry Soroka. | Cal. State Polytechnic Univ. Pomona | bisoroka@csupomona.edu | 714-869-4396 |
| Eduardo A. Misawa | Oklahoma State Univ. | u3144aa@unx.ucc.okstate.edu | |
| Thomas E. Bihari | Adaptive Machine Technologies, Inc. | amt@eagle.eng.ohio-state.edu | |
| Robert Y. Al-Jaar | Systems Eng. &Technology Group, DEC | aljaar@hdlite.dec.com | |
| Michael Kassler | Australian Robot Assoc. | michael@extro.ucc.su.OZ.AU | |
| Tasuo Arai | Robotics Div., Mech.l Eng. Lab. AIST, MITI,Tsukuba, Japan | m2550%mel.junet%kddlab @UUNET.UU.NET | 81-298-54-2518 |
| Kevin Cleary | Robotics Div., Mech. Eng. Lab, AIST, MITI, Tsukuba Japan | m2550%mel.junet%kddlab @UUNET.UU.NET | 881-298-54-2518 |
| Ari Requicha | University of Southern California | requicha@lipari.usc.edu. | |
| David B. Stewart | Carnegie-Mellon Univ. | stewart@faraday.ece.cmu.edu | |
| Thomas Wheatley | Nat'l Inst. of Standards | wheatley@cme.nist.gov | |
| ***Changes*** | | | |
| Kimon Valavanis | Ctr. for Advanced Computer Studies University of SW Louisiana | kimon@cacs.usl.edu | |
| Robyn Bates to Robyn Rebecca MacKenzie | Brookhaven National Lab | robyn@bnlux0.bnl.gov | |

If you would like to be included in the e-mail directory please send the pertinent information to Rosalyn Snyder, roz%hobie@mcnc.org. We are experimenting with sending Calendar announcements via e-mail as it is very difficult to publish them in a timely manner in a quarterly newsletter. We sent this issue's Calendar to our current list on December 18. If you thought you were on our list and did not receive it, we may not have your correct address. Please resubmit.

***From the Control E-Letter***

Matt Wette (mwette@csi.jpl.nasa.gov) has set up a local distribution point for the Control Society electronic newsletter. It is scsp-news@csi.jpl.nasa.gov. The machine csi.jpl.nasa.gov has internet number 128.149.29.4. People on the west coast may email to scsp-news-request@csi.jpl.nasa.gov if they wish to be added to the local distribution for the Control E-Letter.

# Computer Aided Behavior Design

*Thomas C. Henderson*
*University of Utah*

The design and implementation of robot behaviors has received a good bit of attention in the last few years. This is the result of the confluence of several streams of research:

- Real-Time Programming Languages
- Ethology
- Animation
- Physical-Based Modeling
- Robotics, and
- Hardware advances.

Taken together with the major leaps in computation power in workstations, individual researchers can now bring together the diverse representations and systems to pursue real and interesting robotics applications.

At the University of Utah, we have been working for a couple of years on combining these areas into a useful computer aided behavior design tool for robotics. We have developed the Omega-Infinity framework in which the goal is to be able write a behavioral specification in such a way as to permit a logical analysis of the relations between the signals (e.g., to and from clocks, sensors, actuators, etc.), and to be able to test the behavior in a simulated environment that adequately mirrors reality. Thus, goal-oriented physical properties of the behavior can be tested as well as logical properties. We have been studying such languages as Esterel (from INRIA) and COSPAN (from AT&T) in the role of temporal specification tools.

Another area which deserves study if you're into robot behavior design is ethology, the science of animal behavior. Although kinematics and dynamics help us to determine how to control a robot, ethology may help us to understand what to do and why. At least this is probably true for many of the lower level functions of the autonomous agents we intend to create.

Finally, the study of higher-level robot behaviors, e.g., for an autonomous vehicle exploring Mars, requires the ability to adequately model the physical characteristics of both the robot and the world in which it works. The graphics community is making great headway in this area, and we should certainly take advantage of their progress in physical-based modeling.

This line of development is useful across a wide spectrum of behavior levels: from communication protocols to obstacle avoidance. Just as CAD has blossomed for the design of geometry and electronics, we believe that such tools will radically change the study and design of robots.

# What the World Needs is a World Robot Project

*Avi Kak*
*Purdue University*

I suppose when times get lean, people start daydreaming. And, these are indeed lean times for robotics, at least in the US. While at one time, not too long ago, robotics was considered to be the do-or-die solution to productivity enhancement in the factory, today only die-hards adhere to that claim.

The truth of the matter is that there never was and probably there never will be a quick answer to productivity enhancement. Another truth is that robotics today represents a natural progression in the continual development of more and more capable machines, a progression brought about very naturally by advances in computers on the one hand and electromechanical systems on the other. Therefore, despite the waning of the enthusiasm shown by the business community and funding agencies, research and development in robotics will continue, albeit at a slower pace.

This brings me back to the subject of daydreaming -- my own daydreaming in particular. While impressive progress has been made during the last decade in all aspects of robotics -- witness the progress in kinematics, dynamics, path planning, dextrous manipulation, sensor-based manipulation, and others -- much still remains to be done in order to make robots useful on a much wider scale in industry. Many of us in the research community believe that the real challenges in robotics will be conquered only through close cooperative work between people from a large number of distinct but interrelated specialties. What I visualize is an intellectually charged environment, inhabited by researchers with specialties in many areas, such as the materials of which robots can be made, the actuation mechanisms, the distributed computation for control, the sensors for measuring both the internal states and for keeping track of the environment, the software reasoning architectures for solving temporal and spatial problems, etc. (Of course, this team of researchers will work in concert with cognitive psychologists, neurobiologists, behaviorists, ethologists, etc.) While the different members of such a team would bring to bear their own specialties on the overall problem, they would derive much pleasure from entertaining flights of scientific fancy in their attempts to accommodate the best of what the other members of the team might have to offer. Such a team, not at all conservative in its thinking, would be willing to launch experimental projects, no matter how risky at the outset, simply to try out new ideas.

For obvious reasons, this type of effort would be too expensive for any organization to support single-handedly, especially due to the heavy emphasis on bold new experimentation. What we would need would be for the most dedicated researchers from around the world to somehow pool their ideas, their efforts, and their resources, working together cohesively towards a common goal. A complex, formidable mission indeed, and expensive to boot -- the very stuff of daydreams.

# Around the World: Reports from Research Institutes

## *Poznan Technical University Poland*

***Prof. A.Wozniak, Director***
***ul.Piotrowo 3a 60-965; Poznan***
***Poland***
***Phone:4861782365 or 782563***
***Telex: 0413250 POLPO PL***
***Fax: 4861330217***

While the laboratory was established in January 1990, the academic staff have been involved in teaching and research for five years. Courses offered to students in electrical engineering include kinematics, dynamics, robot control, programming of robots, trajectory planning, computer vision and AI. An educational robot, ROMIK, has been completely designed and built in the laboratory. ROMIK has five degrees of freedom and is driven by 6 stepmotors. Maximum dynamic load is1 kg. Autonomous control of the robot is assured by an internal single board computer based on a Z80 microprocessor. Supervision control is performed by an IBM PC/AT through serial RS-232 board. Implementation languages were Prolog and Pascal. ROMIK was designed for teaching, palletizing and performing automatic quality control duties (measurements). The laboratory is also equipped with an ASE AIRp-6 industrial robot with a welding system and a Cartesian robot PR-02. Current research activities are concentrated in the following areas:

- ***Computer vision system, Dr.A. Florek.***

The focus of the image processing group is the design of the modular TV system working with the AMS-Mbus. Software projects are concentrated on the objective classification (quality control) of the beef or pork half carcasses based on the analysis of the TV picture. Software packages for calculating the thickness of the fat of the carcass have been completed.

- ***Kinematics of redundant manipulator-control of robots. Dr.A. Kasinski.***

This research is concentrated on external trajectory reproduction for manipulators with degenerate kinematics. Very efficient software packages for inverse kinematic problems for redundant manipulators have been completed. The synthesis of the nonlinear state-feedback control law for automatic generation of the solution has been examined (for two and three degrees of freedom robots and inexpensive microcomputer controllers). The integrated program system for creating geometrical models, solving inverse and direct kinematics problems, robot trajectory synthesis and computer animation of robot scene pictures written in Pascal for IBMPC/AT computers has been obtained

- ***Adaptive control systems; system identification; input signal design, Dr. A. Krolikowski,***

This research includes: elaboration of adaptive control algorithms with emphasis on the case when the inputs are amplitude constrained; analysis and synthesis of parameter and structure identification procedures; design of bounded inputs for system identification; and computer simulation and implementation of control and identification algorithms.

*•Robot dynamics algorithms and model-based control of a robot manipulator: Dr. K. Kozlowski.*

This research is focused on computational requirements for a discrete Kalman filter in robot dynamics algorithms. An experimental facility now being built consists of an ASEAIR p-6 robot, force/torque sensor and sensorball (developed by DFVLR, German Aerospace Research Establishment, Wessling, Germany), and a measuring station for the ASEAIR p-6 robot. Identification of the model of the ASEA IRp-6 robot is now in progress. Assessment of the effectiveness of various adaptive control algorithms experimentally applied to this robot and their robustness to modeling errors, given the estimated dynamic model, are studied.

*•Robot simulation and programming system: Dr.J. Warczynski.*

The system includes six program modules: geometric model editor; programming module; dynamic model generator; model for modeling of execution devices, sensors, and control loops; graphic presentation module. The system also includes help programs and information. The system operates in the framework of three main modes: modeling, programming, and simulation. The system was developed to assist programming robots, workcell and particularly model-based dynamic performance evaluation.



## LIRA Lab: University of Genova, Italy


*G. Sandini*
*DIST-University of Genova*
*Via Opera Pia 11A*
*116145 Genova Italy*
*Tel: 39 10 3532983*
*Fax: 39 10 353 2948*
*e-mail:lira@dist.unige.it*


The LIRA-Lab (Laboratorio Integrato di Robotica Avanzata) operates in the engineering faculty and coordinates the activities of people with different backgrounds: artificial intelligence, control theory, bioengineering. The emphasis is on unconventional applications in unstructured environments, but also more classical robotic and automation topics are carried out in cooperation with various automation industries in the Genova area.

Basic equipment includes:

- Sapri robot, model Earnest-zero (6 dof, 10 Kg payload)
- Six degrees of freedom arm (DIST-arm)
- In-house developed mobile base
- Stereo & dynamic vision processing equipment (VDS 7001 Eidobrain)
- 2 HP 9000 workstations
- 2 SUN Sparcstations
- Masscomp with real-time Unix
- Meiko Computing Surface (36 nodes, 100 Mb)
- Siemens Prolog Machine

### *Robot Control*

The robot control group research activities at DIST are performed in three different, but highly correlated areas:

- Dynamic Modelling and Simulation of Robotic Structures
- Robot Control Theory, and
- Prototypes Development and Experimental Activities

In Dynamic Modelling, the attention is focussed on the realization of reliable software capable of handling complex mechanical structures, such as Multirobot architectures, possibly characterized by legged/wheeled locomotion systems or floating capabilities (as in the cases of submarine or space applications), where specific phenomena such as impacts, changes of structures (opening or closure of kinematic chains), etc., must be explicitly kept into account.

In the Robot Control Theory area typical items, such as nonlin-

ear, possibly adaptive robot control problems are studied from both methodological and algorithmic points of view. Special interest is given to particular cases, such as hybrid (position and force) control for manipulators, and dynamic equilibrium control within the field of legged locomotion.

In particular a good experience has been gained with respect to novel methodologies; namely the so-called "Iterative Learning Techniques", whose assessment has been partially contributed by the DIST (Departimento di Informatica, Sistemistica e Telematica) control group itself.

The third area, Prototype Development, etc., refers to all activities devoted to the implementation and experimental evaluation of control techniques, when applied to specific real case studies.

Toward these aims, various systems, such as a 7 DOF manipulator, a wheeled vehicle, and systems for dynamic equilibrium control experimentation, have been specifically developed and are currently used as prototype demonstrators within the lab.

***•Neural Control of Pseudo-Muscular Actuators***

The neural controller that we are developing is based on "Passive Motion Paradigm" (PMP) [Mussa Ivaldi, Morasso, and Zacaria 1988], which states that whatever the kinematic complexity of a motor system, if the actuators have viscous-elastic properties, then the synergy of actuator commands necessary to carry out a desired movement can be obtained via the simulation of a possible movement, i.e., the movement determined by an external disturbance (the elastic properties of muscles provide an effective analog mechanism for distributing the motion to all the parts according to the least variations of potential energy). The mechanism that is being investigated for implementing the PMP [Morasso, et al. 1990] is a relaxation network that is attracted by configurations of minimum potential energy.

***•Intelligent Motor Control, Action Representation and Planning***

Different topics related to motion in unstructured environments and/or uncertainly formulated goals are investigated, linked by a common approach: navigation, dextrous grasping, redundant structures, collision free arm movements, and sequence planning. The common approach consists of a set of analogic models at the different levels (actuators, joints, Cartesian space, plan constraints) and a set of mappings between the variables in the different spaces (forces, joint variables/torques, Cartesian variables/forces, and "virtual" forces describing constraints). Solving a problem is negotiating inside the multi-dimensional space.

The general problem of navigation is solved using Force Fields and Flux Fields. Heuristics are used to jump over local minima and to find optimal paths. The same paradigm is used to generate redundant motion, including interaction with objects, for models of dexterous grasping in particular. Analogic models are also used in devising action sequences when goals and constraints can be described in terms of (virtual) forces. This is the highest level of action descriptions; it is interfaced to higher symbolic levels, in which reasoning (in the AI sense) is demanded. The reference paradigm is the Assembly Planning; the symbolic level of description and reasoning is handled by a Semantic Multi-Inheritance Network (KL-ONE) with added temporal semantics, implemented on a Prolog Machine.

***•Robotic Vision***

Among the aspects of artificial vision exploited for robotic applications is dynamic 3D vision for developing medium-range navigation strategies. Stereo and motion algorithms coupled with fast processing boards are developed for short range navigation (namely obstacle avoidance).

Other activities of the vision group include the development of smart sensors. Currently, a CCD retina-like imaging sensor is being fabricated within a project led by DIST, in collaboration with European and US partners. The application of the sensor to a variety of visual tasks is under investigation. Several applications have already been developed, such as the processing of dynamic image sequences aimed at target tracking or depth estimation and the recognition of 2D shapes from single images. Within this framework the paradigm of active vision is being pursued as an essential sensing strategy. Some activities involve the area of agricultural robotics: visual algorithms are being developed for greenhouse robotic applications. Other activities relate to the cooperation of visuo-motor strategies for manipulation tasks. In this context active movements are considered to reduce the complexity and improve the output of the visual processing. Vision and manipulation, but also vision and action (like ego-motion) are also considered together in a more general framework as very powerful methods for scene understanding.

***•Artificial Muscles (Polymeric Pseudo-Muscular Actuators)***

The aim is the development of polymeric actuators which exhibit viscous-elastic characteristics similar to biological muscles. Polymer gels (which consist of a polymer network and liquid) are characterized by interesting chemical-electrical-mechanical properties that were already known in the early fifties. The contraction is determined

by the diffusion of ions inside the polymeric matrix that causes a rearrangement of the (electrically charged) matrix and the production of mechanical work. The research is carried out in collaboration with Prof. D. De Rossi of Pisa University.

***•Funding Sources and International Collaborations***

The LIRA-Lab is supported by many public and private organizations, including the Italian government, IBM Italia, Ansaldo S.p.A., ELSAG S.p.A., and the European Community.The faculty are engaged in collaborative research with colleagues at European and United States research institutes under the auspices of ESPRIT, NATO, CNR and private industries.

## *The ARTS Lab: Scuola Superiore S. Anna, Pisa, Italy*

*Paolo Dario*
*Scuola Superiore di Studi Universitari e di Perfezionamento S. Anna,*
*via Carducci 40, 6100 Pisa*

The primary long-term goal of the ARTS (Advanced Robotics Technology & Systems) is to investigate robotics systems primarily capable of operating in unstructured and unpredictable environments: "Advanced Robots". Since the development of those robots requires the study of the different components (hardware and software) necessary to obtain flexible and adaptive behavior, particular attention is given to the technological problems associated with the development of sensors (proximity, contact, touch), actuators, mechanical structures, etc. Special equipment are available in the laboratory to fabricate and test such devices. Other areas, such as the mechanical design of robot structures, force control methods, multiprocessing computer architectures, and manipulation are also investigated as key factors for the achievement of intelligent behavior in robotic systems.

Specific application areas considered for the above robotic systems outside the factory floor include agricultural, medical and space robotics.

# Conference Reports

## *Applications of Artificial Intelligence VIII*

*Orlando FL, April 17- 19, 1990. Sponsor: (SPIE) in cooperation with the IEEE Computer and IEEE Systems, Man, and Cybernetics Societies. Chairman: Prof. Mohan Trivedi, University of Tennessee.*

The more than 100 technical papers presented at the conference emphasized practical and engineering aspects associated with AI techniques.

Audience participation was generally higher for three-dimensional and model-based vision, neural networks, expert systems, and intelligent robotic systems sessions. In addition, the use of AI techniques in VLSI fabrication and testing systems drew substantial response from the attendees.

The first keynote speaker, Prof. Benjamin Kuipers from the University of Texas at Austin, spoke on "The Use of Qualitative Simulation in Support of Model-Based Reasoning".

Kuipers stressed how qualitative modeling and simulation methods can be used for model-based systems which utilize incomplete quantitative knowledge. Further, he added that qualitative differential equations were successfully used in eliminating spurious predictions during simulation. However, realistic complex system must be broken down into simpler mechanisms before it is possible to qualitatively simulate them.

Prof. Bernard Widrow, who pioneered the advances in adaptive signal processing systems three decades ago, spoke on "The Truck Backer-Upper: An Example of Self-Learning in Neural Networks," Using this example, he showed how test cases such as the truck backer-upper graphically demonstrate the use of neural networks to design highly non-linear controllers. The design of such controllers is not possible using standard control theory techniques. Self-learning techniques were utilized to determine the internal parameters of the nonlinear controller. The present technique is, however, limited to training problems involving only a small number of degrees of freedom.

In his talk, "Highly Interactive Computing Environments: The Next Wave" Prof. Elliot Soloway, from the University of Michigan discussed ways learning skills of young students can be enhanced by way of integrating computers as a key feature in their educational environment.

Citing the rapid progress in computer technology, Soloway argued that the environment in which young students are functioning today is completely different from the environment in which most of the educators were trained. This challenges us to find the appropriate models and mechanisms for the best educational experience that we can provide the young students.

The conference proceedings are available through SPIE, Bellingham, Washington (Vol. 1293).

*--Hrishkesh P. Gadagkar and Mukul V. Shirvaikar, University of Tennessee*

# 1991 IEEE INTERNATIONAL CONFERENCE ON ROBOTICS AND AUTOMATION

Sponsored by the IEEE Robotics and Automation Society

**April 7-12, 1991**
**Hyatt Regency Sacramento**
**Sacramento, California**

General Chairperson: **T.C. Hsia,** University of California, Davis
Program Chairperson: **T.J. Tarn,** Washington University
Program Vice-Chairpersons: **Katsuhisa Furuta,** Tokyo Institute of Technology
**Randy Phillips,** G.E. Corporation
**Harry E. Stephanou,** Rensselaer Polytechnic Institute

Treasurer and Coordinator: **Harry Hayman**
Local Arrangements: **Doug Boone,** Hewlett Packard

## Program Committee

P. Allen
Columbia University
E. Bayo
University of California, Santa Barbara
G.A. Bekey
University of Southern California
M. Brady
University of Oxford
Y. Chen
G.M. Research Laboratories
J. Crisman
Northeastern University
A.A. Desrochers
Rensselaer Polytechnic Institute
M. Erdmann
Carnegie Mellon University
T. Fukuda
Nagoya University
P. Goel
N.S.K. Corporation
A.A. Goldenberg
University of Toronto
W.A. Gruver
University of Kentucky
S. Hayati
California Institute of Technology
V. Hayward
McGill Research Center
G. Hirzinger
DFVLR, Germany
J.M. Hollerbach
McGill University
H. Kazerooni
University of Minnessota
O. Khatib
Stanford University
P.K. Khosla
Carnegie Mellon University
R.D. Klafter
Temple University
A.J. Koivo
Purdue University
M.B. Leahy, Jr.
AirForce Institute of Technology
B.H. Lee
Seoul National University
S. Lee
University of Southern California
C.H. Liu
National Taiwan Inst. of Technology
P. Luh
University of Connecticut
J.Y.S. Luh
Clemson University
V.J. Lumelsky
Yale University
M.T. Mason
Carnegie Mellon University
J. Mills
University of Toronto
H. Moraff
National Science Foundation
H. Mukai
Washington University
C.P. Neuman
Carnegie Mellon University
F. Nicolo
University di Roma, Italy
D. Orin
Ohio State University
M.H. Raibert
Massachusetts Institute of Technology
G.N. Saridis
Rensselaer Polytechnic Institute
E. Schmitz
Martin-Marietta
W. Snyder
North Carolina State University
S.A. Stansfield
Sandia National Laboratories
H.W. Stone
California Institute of Technology
J. Sztipanovits
Vanderbilt University
R. Taylor
IBM T.J. Watson Research Center
K. Valavanis
Northeastern University
M.W. Walker
University of Michigan
K. Youcef-Toumi
Massachusetts Institute of Technology
X. Yun
University of Pennsylvania
Y.F. Zheng
Ohio State University

Automation And Manufacturing In The 90's
International Cooperation

Tuesday, April 9, 1991 to
Thursday, April 11, 1991

## CONFERENCE

The contributed papers to be presented at the conference cover a variety of topics. They include the following subjects:

Robot dynamics and control
Robot kinematics and mechanisms
Intelligent automation and manufacturing
Sensing, sensor fusion and sensor applications
Dextrous manipulations and grasping
Flexible manipulators
Mobile robots, planning and control
Telerobotics
Trajectory planning, collision avoidance
Application of artificial intelligence and neural network

**The following INVITED SESSIONS are being organised:**

1. **Underwater Robotics,** J. Yuh, University of Hawaii at Manoa
2. **Coordination of Multiple Industrial Robots,** Y.F. Zheng, Ohio State University
3. **Control and Human-Machine Interaction in Teleoperation,** E. Colgate, Northwestern University and H. Kazerooni, University of Minnessota
4. **Scheduling of Manufacturing Systems,** D.J. Hoitomt, University of Connecticut, Storrs
5. **Sensing and Control for Automation,** T.I. Liu, California State University, Sacramento
6. **Spatial Operator Algebra,** K. Kreutz-Delgado, University of California, San Diego
7. **Feedback Control of Nonholonomic Mobile Robots,** C. Canudas-de-Wit, ENSIEG, France
8. **Programming Environments for CIM,** W.A. Gruver, University of Kentucky
9. **Distributed Intelligent Robotic System,** T. Fukuda, Nagoya University, Japan
10. **Optimal Design and Kinematics,** P.S. Krishnaprasad, University of Maryland
11. **Real Time Fault Diagnostics,** J. Sztipanovits, Vanderbilt University and E. Scarl, Boeing Computer Services
12. **Neuromorphic Control and Identification of Robots,** J.J. Helferty, Temple University
13. **Flexible Production Systems,** F. Nicolo, University di Roma, Italy
14. **VLSI-based Robotic Sensors,** T.Kanade, Carnegie Mellon University
15. **Human-like Design for Robotics,** L. Stark, University of California

**First Plenary Speaker, Tuesday**
Dr. A. Bensoussan
INRIA
France

**Second Plenary Speaker, Thursday**
Prof. Hirofumi Miura
University of Tokyo
Japan

**Banquet Speaker**
Dr. Craig R. Barrett
Executive Vice President
Intel Corporation

**Coordinator of Invited Sessions:** H. Moraff, National Science Foundation and T.J. Tarn, Washington Univ.
**Coordinator of Tutorials and Workshops:** H. Stephanou, RPI and T.J. Tarn, Washington Univ.

## Workshop S1 - (Sunday, April 7, 1991 - 1:00 PM to 6:00 PM)
### Intelligent Sensory Processing for Space Based Robotics

The purpose of this workshop is to review the state-of-the-art in intelligent sensory processing systems in space applications of robotics and automation. Recently the need for robotic systems in space has been highlighted by the extensive requirements for extra-vehicular maintenance on the Space Station Freedom. The workshop will focus on the development and integration of various emerging technologies to supporting national and international space programs. These programs include the construction and operation of the Space Station Freedom, as well as robot-assisted exploration of the lunar and planetary surfaces. Intelligent sensory processing will be discussed through presentation of current theoretical results and practical applications addressing areas such as real-time environments, high reliability requirements and application complexity. These sensory processing systems represent structural behavioral, functional characteristics of the environment and interpret the sensory input signals in the context of detailed models.

Organizer: James R. Carnes, Vanderbilt University
Speakers: Rui J.P. deFigueiredo, University of California, Irvine
John M. Vranish, NASA Goddard Space Flight Center
David G. Hunter, Canadian Space Agency
David P. Miller, Jet Propulsion Laboratory
James R. Carnes, Vanderbilt University
William S. Davis, Boeing Computer Services
Csaba Biegi, Vanderbilt University

## Workshop S2 - (Sunday, April 7, 1991 - 2:00 PM - 5:00 PM)
### Intelligent Robotic Systems: Theory Design and Applications

The purpose of this workshop is to present and describe analytically a unified theory for the design, modeling and analysis of Intelligent Robotic Systems. Both heuristic and analytical methodologies are considered. Applications are used to justify the theoretical framework. The overall approach is shown to be modular. The important robot payload variation problem is investigated as part of the overall system design with the aid of a novel 4-parameter controller methodology. A brief description of other modeling methodologies is also presented and compared.

Organizer and Speaker: Kimon P. Valavanis, Northeastern University

## Tutorial M1 - (Monday, April 8, 1991 - 9:00 AM - 5:00 PM)
### Petri Nets for Automated Manufacturing Systems: Modeling, Control and Performance Evaluation

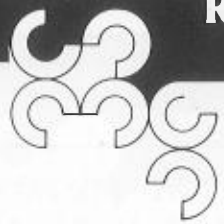
The development, validation and performance analysis of modern manufacturing control systems requires skills and techniques beyond those normally obtained in a university education environment. The introduction of flexible technology and computer integration into factories challenge the engineers and managers whose responsibility it is to coordinate and synchronize these production facilities. Research and development over the last two decades has provided new theory and graphical tools based on Petri nets and related concepts. The purpose of this tutorial is to present the theory, its implementation and examples of applications to the modeling, discrete event control and performance analysis of manufacturing systems. Currently available software tools based on Petri net approach will be reviewed and assessed.

Organizer: Alan A. Desrochers, Rensselaer Polytechnic Institute
Speakers: Alan A. Desrochers, Rensselaer Polytechnic Institute
Frank DiCesare, Rensselaer Polytechnic Institute
Manuel Silva, Universidad de Zaragoza, Spain

## Tutorial M2 - (Monday, April 8, 1991 - 9:00 AM - 5:00 PM)
### Neural Networks for Intelligent Robotics Systems

The goal of this tutorial is to develop a fundamental understanding of neural networks, the underlying concepts, and their major applications. Basic concepts of artificial neural networks are covered from both nonlinear dynamical systems and the information processing capability points of view. Network topologies, characteristics of individual processing elements and the well known learning rules are discussed. Application of neural networks in pattern recognition, models of neural compensation in motor control, as well as intelligent control in robotics and manufacturing are reviewed.

Organizer and Speaker: Behnam Bavarian, Univ.of California, Irvine



## Tutorial M3 - (Monday, April 8, 1991 - 9:00 AM - 12:00 Noon)
## Piezoelectric "Smart" Systems - Applied to Robotics, Micro Systems, Identification, and Control

In the recent development of "smart" structures and micro-electro-mechanical systems, piezoelectrics have proved to be sensitive, responsive, and versatile in many applications, e.g., flexible robots, distributed sensors, distributed actuators, modal sensors/actuator, micro-sensors/actuators, micro-drivers, micro-positioning devices, etc. This tutorial focuses on four objectives: 1) surveying state-of-the-art research results, 2) reviewing fundamental theories and tools, 3) demonstrating practical applications, and 4) discussing new research and development directions.

Organizers: H.S. Tzou, University of Kentucky
Toshio Fukuda, Nagoya University
Speakers: Toshio Fukuda, Nagoya University
T. Higuchi, University of Tokyo
K.M. Lee, Georgia Institute of Technology
H.S. Tzou, University of Kentucky

## Tutorial M4 - (Monday, April 8, 1991 - 2:00 PM - 5:00 PM)
## Modular Architecture for Robot Structures

The critical issue facing designers of advance robot architectures is how to take advantage of advanced electronic technology (encoders, arithmetic chips, high speed processor boards, etc.) to produce generic and more versatile mechanical robot structures at lower costs. Today, almost all robots are designed one at a time at exceptionally high cost of resources and time. Frequently, this level of investment induces the designer to be conservative, leading him to use only proven technologies—hence, his system is not only costly but frequently obsolete and cannot easily be redesigned when new technology becomes available. The pressing need is to achieve an architecture which can rapidly evolve in the same fashion as is now feasible of personal computers. The goal of this tutorial is to show how a highly structured modular approach to robot architecture can achieve these desired results. The tutorial begins by reviewing a diverse range of existing robot technology in order to demonstrate architectural principles that are being employed or are in development. The second part of the tutorial shows how to build a generalized mechanical architecture out of 1, 2 and 3-DOF structural modules driven by a finite set (3) of compact, lightweight, stiff and redundant actuator modules. This resulting architecture is easily scaled, assembled, and multilayered, which should dramatically lower costs and provide significantly improved performance without long design-to-market cycles and the implied threat of obsolescence.

Organizer and Speaker: Delbert Tesar, University of Texas at Austin

## Workshop F1 - (Friday, April 12, 1991 - 9:00 AM - 5:00 PM)
## Manufacturing System Control Software Workshop

It is widely acknowledged that software related problems are one of the major impediments to achieving computer integrated manufacturing. The goal of this workshop will be to bring together manufacturing system control software (MSCS) researchers, vendors, and users to discuss the state-of-the-art in this area. The workshop will consist of: (1) a review of software engineering as it applies to MSCS; (2) a review of object oriented approaches to the development of MSCS (with emphasis on Ada and C++); (3)a discussion of distributed and concurrent execution of object oriented programs; (4) a review of state of the art development environments for development of MSCS; (5) a review of data exchange standards (STEP) and the software to implement these standards; (6) a review of the state-of-the-art in MSCS methodologies and architectures.

Organizers: D. Neal Scogin, Texas A&M Univ.
Richard Volz, Texas A&M Univ.
Giuseppe Menga, Politecnico di Torino
Speakers: Jarir Chaar, Univ. of Michigan
Arun Chatterjee, Univ. of Texas
Mario Garielli, Mainstream Software
Michael J. McLay, NIST
Giuseppe Menga, Politecnico di Torino

## Workshop F2 - (Friday, April 12, 1991 - 9:00 AM - 5:00 PM)
## Nonholonomic Motion Planning: Theory, Algorithms and Applications

Over the last decade, there has been a substantial amount of research activity in robot motion planning with constraints on the configuration variables, better known as holonomic constraints. In holonomic motion planning, a robot executes a task with purely geometric constraints, e.g., pick-and-place operations and sliding assembly. Most robotic tasks, however, require physical interaction of the robot with the environment, e.g., mobile robot navigation, grinding and contour following, dexterous manipulation or assembly with a robotic hand and parking a vehicle with or without trailers. Under these circumstances, constraints are imposed on the derivatives of the configuration variables and in general these constraints cannot be reduced to constraints on the configuration variables alone. This class of constraints is known as nonholonomic constraints and it gives rise to a nonholonomic distribution on the configuration pace of the system. Thus, Nonholonomic Motion Planning (NMP) deals with path planning subject to nonholonomic constraints, as well as holonomic constraints. This workshop presents a consolidated development of NMP and examines practical applications or recent research results.

Organizer: J. Canny, Univ. of California at Berkeley
Speakers: J. Burdick, California Institute of Technology
J. Canny, University of California at Berkeley
Z. Li, New York University
J. Wen, Rensselaer Polytechnic Institute

## Workshop F3 - (Friday, April 12, 1991 - 9:00 AM - 12:00 Noon)
## The Application of Robotics to the Handling of Hazardous Wastes, Materials, and Equipment

Teleoperation is the only known method of handling materials and systems, which provide a lethal health threat to human personnel, in an unstructured environment. Examples of such systems and materials are: the day-to-day operation, maintenance, and repair of nuclear fuel reprocessing facilities; the re-packaging and disposal of nuclear waste; and the handling of unstable explosives and chemicals. Recent developments in telerobotics, directed to space and subsea, have application in this critical research area. Important results of research in robotics have application in teleoperation, in many cases providing a new approach resulting in the improvement of productivity and the simplification of operator interfaces. This workshop will include presentation on needs in the nuclear industry, and on robotics research approaches to the solution of this important problem.

Organizer: Richard Paul, University of Pennsylvania
Speakers: Ruzena Bajczy, University of Pennsylvania
Antal Bejczy, Jet Propulsion Laboratory
Patrick J. Eicker, Sandia National Laboratories
Pradeep Khosla, Carnegie Mellon University
Richard Paul, University of Pennsylvania
Kenneth Salisbury, Mass. Institute of Technology

## Workshop F4 - (Friday, April 12, 1991 - 2:00 PM - 5:00 PM)
## Computational Methods for Robot Dynamic Path Optimization

There is a significant economic motivation to dynamic optimization in robot path planning. Minimum-time trajectories have the potential to increase robot operating speeds with a corresponding increase in the productivity of assembly lines. Minimum-energy operation also has obvious benefits. The mathematical and numerical complexity of such optimization problems has so far precluded any general use of such dynamic optimization, but recent advances in numerical methods have made it possible to compute time-optimal robot trajectories quickly without requiring large computational facilities or computational effort. These advances make it reasonable to expect that in the future it will be possible for a robot manufacturer to offer a "black box" program package for his robot that computes near optimal trajectories quickly, without requiring any knowledge of control theory on the part of the user. This workshop discusses the numerical methods, possible optimization criteria, robot dynamic modeling, optimal control implementation issues, and gives many examples of time-optimal robot trajectories with physical interpretations.
Organizer: Richard W. Longman, Columbia University
Speaker: Richard W. Longman, Columbia University
H. Georg Bock, University of Augsburg

## EXHIBITS

A limited number of exhibit booths will be available at the Hyatt Regency Sacramento. For further information regarding exhibiting at the conference contact:

**Harry Hayman**
P.O. Box 3216
Silver Spring, MD 20918
Tel: (407) 483-3037
After 3/28/91
Tel: (301) 434-1990

For further information detach and mail this coupon to:
1991 IEEE INTERNATIONAL CONFERENCE ON ROBOTICS AND AUTOMATION

Robotics and Automation
P.O. Box 3216
Silver Spring, MD 20918
(407) 483-3037

Name _____
Organization _____
Address _____
City, State, Zip _____
Country _____

1991 IEEE INTERNATIONAL CONFERENCE ON

## Registration Form

ROBOTICS AND AUTOMATION

**April 7-12, 1991**
The Hyatt Regency Scaramento
Sacramento, California

Please complete and return this form (with your check made payable to "Robotics and Automation") to:

Robotics and Automation
P.O. Box 3216
Silver Spring, MD 20918

Telephone Contact:
Harry Hayman
(407) 483-3037
(After 4/1/91) (301) 434-1990

(Checks must be in U.S. dollars drawn on a U.S. Bank)

Name _____

Company _____

Address _____

City/State/Zip/Country _____

Telephone No. _____
(Where you can be reached during the day)

IEEE Membership Number _____

Please Register me as follows (Circle appropriate fee).

| | Member fee | Non-Member fee | Student fee |
|---|---|---|---|
| Conference | $225 | $275 | $105 |
| Conference (plus Video) | $280 | $330 | $160 |
| Workshop S1 (half day) | $100 | $125 | $100 |
| Workshop S2 (half day) | $100 | $125 | $100 |
| Tutorial M1 (full day) | $125 | $150 | $125 |
| Tutorial M2 (full day) | $125 | $150 | $125 |
| Tutorial M3 (half day) | $100 | $125 | $100 |
| Tutorial M4 (half day) | $100 | $125 | $100 |
| Workshop F1 (full day | $125 | $150 | $125 |
| Workshop F2 (full day) | $125 | $150 | $125 |
| Workshop F3 (half day) | $100 | $125 | $100 |
| Workshop F4 (half day) | $100 | $125 | $100 |
| TOTAL | $___ | $___ | $___ |

Please circle applicable fees for those sessions you desire to attend, then add together to determine total fee which should be included with your registration.

For registration after March 24, 1991 add $50 late fee ($25 for Students).

Payment Enclosed $_____

Payment may be made by Check in U.S. Dollars on U.S. Bank, VISA or Master Card only.

Card No. _____

Exp. Date _____

Signature _____

The tutorials and workshop include coffee breaks and notes.
Conference registration includes the proceedings, coffee breaks, and social functions.
Student registration for the conference only (does not include social functions, but includes coffee breaks and proceedings). To qualify for student rate, students must be IEEE Members and must not be employed full time. Students will be required to show their IEEE Membership card when picking up their registration.
Registration fees may be refunded in full if a written request is received before March 24, 1991. A 50% penalty charge will be levied on those who request a refund after that date and before April 7. After April 7 there **WILL BE NO REFUNDS.** Late registration will be accepted beginning Sunday April 7, 1991 at the Hyatt Regency Sacramento.
Note: The conference plus video includes a copy of the video presentations which will be presented at the conference in a video theatre.

1991 IEEE INTERNATIONAL CONFERENCE ON

ROBOTICS AND AUTOMATION

## HOTEL REGISTRATION FORM

**April 7-12, 1991**
**Hyatt Regency Sacramento**
**Sacramento, California**

Name _____

Company _____

Address _____

City/State/Zip _____

Country _____

Daytime Phone Number _____

Arrival Date and Time _____

Departure Date and Time _____

A Block of rooms for this conference is reserved until March 21, 1991. Reservations received after this date will be confirmed on a space-available basis.
Guest Room Rates
Single or Double $98
Please indicate No. of rooms and single or double_____

**To guarantee your reservation,** please enclose first night's room + tax (to be credited to your account), or a credit card number in the space provided below. Failure to arrive on that day without notification will result in cancellation and forfeiture of deposit or, one night's room charges will be billed to your credit card.

Cardholder's Name _____

Card Type _____

Card No. _____

Exp. Date _____

Signature _____

Mail to: Hyatt Regency Sacramento
Attn: Reservations Department
1209 L Street
Sacramento, CA 95814

Tel: (916) 443-1234
FAX: (916) 448-8686

**CALL FOR PAPERS**

IEEE

1991 IEEE International Symposium on

# INTELLIGENT CONTROL

**August 13-15, 1991**
**Key Bridge Marlott**
**Arlington Virginia**

**Sponsored by the IEEE Control Systems Society**

General Chairman — Harry E. Stephanou, Rensselaer Polytechnic Institute
Program Chairman — Alexander H. Levis, George Mason University

The 6th IEEE International Symposium on Intelligent Control (ISIC 91) will be held in conjunction with the 1991 IFAC Symposium on Distributed Intelligence Systems. Registrants in either symposium will be able to attend all technical and social events in both symposia and will receive preprint volumes from both.

The ISIC 91 theme will be "Integrating Quantitative and Symbolic Processing". The design and analysis of automatic control systems have traditionally been based on rigorous, numerical techniques for modeling and optimization. Conventional controllers perform well in the presence of random disturbances, and can adapt to relatively small changes in fairly well known environments. Intelligent controllers are designed to operate in unknown environments and therefore require much higher levels of adaptation to unexpected events. They are also required to process and interpret large quantities of sensory data and use the results for action planning or replanning. The design of intelligent controllers, therefore, incorporates heuristic and/or symbolic tools from artificial intelligence. Such tools, which have traditionally been applied to open-loop, off-line problems, must now be integrated into the perception-reasoning-action closed loop of intelligent controllers. Effective methods for the integration of numerical and symbolic processing schemes are needed. Robustness and graceful degradation issues must be addressed. Reconfigurable feedback loops at varying levels of abstractions should be considered.

Papers are being solicited for presentation at the Symposium and publication in the Proceedings. Topics include, but are not limited to, the following:

- Intelligent control architectures
- Self-organizing systems
- Fault detection and error recovery
- Intelligent manufacturing control systems
- Discrete event systems
- Concurrent engineering
- Hierarchical controllers
- Neural network controllers
- Learning control systems
- Autonomous control systems
- Knowledge representation for real-time processing
- Reasoning under uncertainty
- Sensor-based robot control
- Cellular robotics
- Microelectro-mechanical systems
- Variable precision reasoning
- Active sensing and perception
- Multisensor data fusion
- Intelligent inspection
- Intelligent database systems
- Microelectronics, advanced materials, and other novel applications

Five copies of papers should be sent by February 15, 1991 to:

Professor Alexander H. Levis
Dept. of ECE, George Mason University
Fairfax VA 22030-4444
Telephone: 703-764-6282

A separate cover sheet with the name of the corresponding author, telephone and fax numbers, and e-mail addresses should also be included. Authors will be notified of acceptance by April 15, 1991. Accepted papers, in camera-ready form, will be due on May 15, 1991.

Proposals for invited sessions and tutorial workshops are also solicited. Cohesive sessions focusing on successful applications are particularly encouraged. Requests for additional information and proposal submissions (by February 15, 1991) should be addressed to Professor Levis.

## *Newsletter Deadline*

***Deadline for the Spring issue is February 15. Email contributions are gratefully received, but should be accompanied by hard copy.***

***Yes, that means that as soon as you receive your newsletter, it is time to send in anything you'd like to see in the next one!***

***Thanks!***

## *Robot Olympics*

***Glasgow, Scotland, September 27-28, 1990. Sponsors: Turing Institute and The University of Strathclyde, Cosponsors: National Westminster Bank and the Scottish Development Agency, In cooperation with the IEEE Robotics and Automation Society.***

From Sylvester McCoy (the current "Dr. Who") to a Masterclass of scholars who discussed "The Future of Intelligent Robots" to a Scottish primary school class, the world's 1st International Robot Olympics was a unique event.

The Opening Ceremonies were marked by the lighting of an Olympic Flame which was lit and carried by the UK National Engineering Lab's "Trolleyman" robot from the Parthenon (a Greek restaurant in Glasgow) to the stadium at the University of Strathclyde. With a media group the size of the White House press corps in attendance, the robot displayed the usual manifestations of Visitor Syndrome and Murphy's Law (*Sod's Law* to the Scots), but eventually succeeded.

The competition attracted 54 entrants and their human minders came from 11 countries: Canada, England, Germany, India, Japan, Mexico, Scotland, USA, USSR, Wales, and Yugoslavia. The entrants walked and trundled, wall-climbed and avoided obstacles for the two days of the event

The 11 competition categories reflected the range and task diversity of the robots that were entered. The categories were: obstacle avoidance, pole balancing, phototrophic sensing, manipulators, biped races, javelin throwing, multi-legged races, wall-following, wall-climbing, speech communication, and behavior. Some of the entrants were versatile enough to enter more than one category.

The overall winner was "Yamabico" from Tsukuba University Japan. The judges also believed that "Yamabico" showed potential for future commercial development, one of the major judging criteria. The free roving mobile robot which has enough on-board computing power to deal with the integrated sensing and task planning requirements needed to perform effectively in an unstructured environment.

Other robotic devices that impressed the judges were "Ghenghis", "Zig-Zag", and "SIAS".

"Ghenghis, the multi-legged device from MIT, with its subsumption architecture and learning capability was the judges' unanimous choice for winner of the Behavior contest.

In complete contrast, "Zig-Zag" from Portsmouth Polytechnic, England, had no on-board intelligence or learning capability. Yet with its clever design, that included only one working muscle, it easily won the wall-climbing contest finals against a wall-climber from the USSR.

SIAS was designed and constructed by Ashish Panwar, a school boy from the City Montessori School in India, He had designed and constructed SIAS in a way that it possessed an amazing range of sensing functions, e.g., counters and moisture detectors, many of which were applicable to household chores.

*--Edward Grant,*
*The Turing Institute*

Those wishing to make a bid to host the 2nd International Robot Olympics should contact Dr. Peter Mowforth, Director, The Turing Institute, George House, 35 North Hanover Street, Glasgow G1 2AD, Scotland, UK. Tel: (+41)552 6400; Fax (+41)552-2985)
E-mail: boffin@turing.ac.uk.

# Calendar

**•January 30-February 2 1991. 4th IEEE Workshop on Micro Electro Mechanical Systems (MEMS)**

NARA, Japan. Sponsor: IEEE Robotics & Automation Society in coop. w/ IEE of Japan and the ASME Dynamic Systems & Control Divisions. Information: IEEE MEMS-91 Workshop, c/o MESAGO Japan Corp., Palais Eternel 1004 28-30 Yotsuya, 4-chome, Shinjuku-ku Tokyo 160 Japan. Tel: 81 3 359 0894 Fax 81 3 359 9328.

**•February 7-9, 1991 ACM ISG-FORTH Workshop**

San Antonio, Texas. Information: Sheli Thomas, Software Construction Co., 2900 Longmire, College Station, Texas 77845.

**•February 24-28,1991. 7th IEEE Conference on Artificial Intelligence Applications. Miami Beach Florida.**

Registration: Ms. Michelle L. Carbone, IEEE Computer Society. 1730 Massachusetts Avenue. N.W. Washington DC 20036-1903. Phone: (202) 371-1013; Fax: (202)728-0884.

## *Calendar (continued)*

**•March 12-15, 1991 Manufacturing Systems: Modeling, Control and Performance Analysis Using Petri Nets.**
*Sponsor:* Rensselaer Polytechnic Institute Office of Continuing Education. *Information:* Joan Masterson (518)276-8351.

**•March 13-15 1991, Joint International Conference on Factory Automation and Information Management (FAIM91),**
Limerick, Ireland. Sponsors: University of Limerick and Virginia Polytechnic Institute and State University. Contact: Ms. Miriam Shine, Dept. of Mechanical & Production Engineering, University of Limerick, Plassey Technological Park, IRELAND. Tel.: 353 61 333644, Telex 500 70609, FAX 353 613 0316 16

**•April 7-12, 1991. IEEE International Conference on Robotics & Automation. Sacramento CA.**
• Sponsor: IEEE Robotics & Automation Society. SEE ANNOUNCEMENT.

**•May 20-24, 1991, ISATA, International Symposium on Automotive Technology and Automation**
Florence, Italy. *Sponsors:* 40 companies and research groups. *Information:* ISATA Secretariat, 42 Lloyd Park Ave., Croydon, Surrey CRO 5SB, England. Tel: 081-686 1329 Fax: 081-686 1490.

**•June 2-3, 1991, IEEE Workshop on Directions in Automated "CAD-Based" Vision.**
*Contact:* Linda Shapiro (shapiro@cs.washington.edu), General Chairman, Dept. of Computer Science and Engineering, University of Washington, Seattle, WA 98195.

**•June 18-20, 1991. International Ocean Technology Conference.**
Glasgow, Strathclyde, UK. *Contact:* Claire Bowie, IOTC Organizing Committee, 9 Royal Crescent, Glasgow G3 7SP, Strathclyde UK, Tel: 041-332-0193.

**•June 20-22, 1991. 5th International Conference on Advanced Robotics: Robotics in Unstructured Environments.**
Pisa ITALY. Sponsor: CNR (Nat'l Research Council of Italy} and others. ***Information***: Prof. Paola Dario '91 ICAR Secretariat, Consorzio Pisa Ricerche, Via Risorgimento 9, I-56126, Pisa Italy.

**•June 23-28, 1991, EURISCON 91: The European Robotics and Intelligent Systems Conference.**
Corfu, Greece. *See Calls for Papers.*

**•August 1-3, 1991, IEEE International Conference on Systems Engineering,**
***Special Session on Reconfigurable and Reusable Real-Time Systems*** Wright State University, Dayton, Ohio. Session Co-Chairs: David B. Stewart, CMU (412)-268-7120
stewart@faraday.ece.cmu.edu and Thomas Wheatley, NIST, (301)-975-3449, wheatley@cme.nist.gov.

**•August 24-30, 1991. 12th International Joint Conference on Artificial Intelligence.**
Sydney, Australia, Sponsor: IJCIA, Inc.; Cosponsor: National Committee on Artificial Intelligence and Expert Systems of the Australian Computer Society. ***Information:*** Prof John Mylopoulos or Prof. Ray Reiter, Dept. of Computer Science, University of Toronto,Toronto Ont. M5S 1A4 CANADA, Fax (+1 416)978-1455 email: ijca-i@cs.Toronto, Toronto.edu

**•October 16-18 1991. 2nd International Conference on Microelectronics of Neural Networks.**
Munich, Germany. *See Calls for Papers*)

**•November 3-5 1991. IEEE International Workshop on Intelligent Robots and Systems 91 (IROS'91).**
Osaka Japan. *See Calls for Papers.*

# Calls for Papers

•**EURISCON 91: The European Robotics and Intelligent Systems Conference,** Corfu Hilton International, Corfu, GREECE, June 23-28, 1991.

Receipt of Abstracts: **February 15, 1991** Acceptance / Rejection: March 31, 1991 Receipt of Full Papers: May 31, 1991

For more information contact

Prof. Tzafestas, National Technical University of Athens, Greece, Tel: +30-1-7757504; FAX: +30-1-7784578 or 6532023, *or within the U.S.* Prof. Kimon P. Valavanis, The Center for Advanced Computer Studies, University of SW Louisiana. Tel: (318) 231-6284; Fax: (318) 231-5791.

• **2nd International IEEE Conference on Microelectronics of Neural Networks.** Munich. October 16-18, 1991.

This conference is dedicated to hardware for neural networks and discussion of implementation constraints introduced by application, technology, and system environment.

Categories for submissions include, but are not limited to: Potential Technologies, Hardware oriented modelling and simulation, VLSI adequate design of neural algorithms, System and chip architectures, CAD for neural chip design., Neural interfaces and sensors.

Send five copies of a 3000-word abstract (not including figures) plus a cover page indicating title, author's name, affiliation, address and phone number should be sent by **May 31** to Dr. Ulrich Ramacher, Siemens AG, Corp. R&D, ZFE ME MS 32, Otto-Hahn-Ring 6, 8000 Munich 83, Telephone: 49 89 636 41296, Fax: 49 89 636 41442

**International Workshop on Intelligent Robots and Systems 91 (IROS'91)** Osaka, Japan, November 3-5. Topics of interest include but are not limited to: Analysis for Robot Tasks, Task and Motion Planning, Robot Languages, Intelligent Motion Control, Hand-Eye Systems, Learning, Adaptive and Self-Organizing Systems, Neural Networks, Man-Machine Interface, Sensor Fusion, AI Techniques for Intelligent Robots and Systems.

Send 4 copies of an 800 word summary for review by **March 31** to: Prof. Hirokazu Mayeda, Osaka University, Faculty of Engineering Science, Toyonaka, 560 Japan. Phone: 81-6-844-1151(ext 4632); Fax 81-6-857-8664 E-mail: d63314a@ccsun01.center.osaka-u.ac.jp.

**IEEE Robotics & Automation Society**

ROBOTICS AND AUTOMATION

THE INSTITUTE OF ELECTRICAL
& ELECTRONICS ENGINEERS, INC.
445 HOES LANE
PISCATAWAY, N.J. 08854

NON-PROFIT ORGN.
U. S. POSTAGE
**PAID**
Richmond, Va.
Permit No. 1193