ROBOTICS AND AUTOMATION

Newsletter of the IEEE Council on Robotics and Automation

Constituent Societies of the Council
Industrial Applications
Industrial Electronics
Components, Hybrids, and Manufacturing Technology
System, Man & Cybernetics
Computers
Control Systems
Aerospace and Electronic Systems

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1987 Conference Chairman: **Prof. Y.C. Ho,** *Harvard Univ.*

From the Editor:

Here you have it, the first issue of the IEEE Robotics and Automation Newsletter· You can see the sort of news we are including. We are now soliciting more technical articles, such as reports on work in progress, laboratory descriptions, new product announcements, and book reviews, as well as whatever news our readers send in.

Our distribution is to all the subscribers to the Journal of Automation and Robotics, about 7000 strong. If you wish to submit something for the next issue, get it to me by May 15th.

As you can tell from this issue, one big piece of news is the R & A conference, to be held March 30th-April 3rd. I am the local arrangements chairman, and that's been keeping me pretty busy. It's going to be the best conference ever, so *get your reservations in early.*

I would like to express my appreciation to Rosalyn Snyder and Annette Beach, who really did most of the work in putting this newsletter together.

1988 IEEE INTERNATIONAL CONFERENCE ON

ROBOTICS AND AUTOMATION

April 25-29, 1988
Franklin Plaza Hotel
Philadelphia, PA

Sponsored by the IEEE Council on Robotics and Automation

General Chairman: **T. Pavlidis,** SUNY at Stony Brook, NY
Program Chairman: **R.B. Kelley,** Rensselaer Polytechnic Inst.
Treasurer and
Coordinator: **Harry Hayman**
Local Arrangements: **R.P. Paul,** University of Pennsylvania

ADVANCE ANNOUNCEMENT
and
CALL FOR PAPERS

Basic and applied papers in all areas of robotics and automation are solicited. Specific topics include, but are not limited to the following:

- Computer Vision in Robotics: Recognition, Inspection and 3D Interpretation
- Robotic Sensing: Touch, Range, Force; Multisensor Fusion
- Robot kinematics, dynamics, and control
- Task Planning and strategies for manipulation—design of robot hands
- Robotic and Automation Systems design, planning, modeling, evaluation, and integration
- Flexible manufacturing systems and flexible automation
- Simulation languages and methods, geometric modeling, and graphical animation
- Robot programming languages, algorithms, and computational architectures
- Planning and scheduling in automated manufacturing
- Man-machine interface
- Mobile robots: design, navigation, planning and applications; Legged Locomotion
- Expert systems in design, diagnosis, and planning
- Application of robotics: industry, space, medical prosthetics, construction, underwater, hostile environments

The organizers encourage the submission of noncommercial papers from representatives of industry, universities, research institutions, and government. All authors will be expected to assist in the review process by reviewing two papers for each paper submitted.

PAPER SUBMISSION: Four copies of long papers (about 15 to 20 double spaced pages including figures) or short papers (about 5 to 7 double spaced pages including figures) should be sent by September 15, 1987 to: **Robert B. Kelley**
ECSE Department
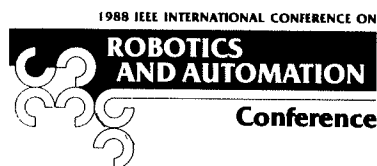Rensselaer Polytechnic Institute
Troy, NY 12180-3590

Papers of excessive length will be returned without review.

Authors will be notified of acceptance and furnished with an author's kit by December 1, 1987. Final papers in camera-ready form will be due January 15, 1988. Final papers received by the deadline will be included in the proceedings available at the conference.

The conference hosts tutorials on Monday, April 25, 1988 and a workshop and tours on Friday, April 29, 1988. Conference sessions will be held on Tuesday, April 26 to Thursday, April 28, 1988. Prior to August 1, 1988, those with proposals for tutorials or the workshop should contact: **Alan Desrochers**
ECSE Department
Rensselaer Polytechnic Institute
Troy, NY 12180-3590

For further information detach and send this coupon to:

1988 IEEE INTERNATIONAL CONFERENCE ON

ROBOTICS AND AUTOMATION
Conference

c/o Harry Hayman
738 Whitaker Terrace
Silver Spring, MD 20901
Telephone (301) 434-1990

Name _____

Organization _____

Address _____

City/State/Zip _____

Country _____

THE INSTITUTE OF ELECTRICAL
AND ELECTRONICS ENGINEERS, INC.

IEEE

The President's Letter

Antal K. Bejczy
1987 President
IEEE Council on Robotics and Automation

This Newsletter is being sponsored by the IEEE Council on Robotics and Automation. The Council was formed in 1984 with the intention to provide a focus for IEEE activities in these technical fields. The publication of this Newsletter is to serve that general intention in the rapidly growing and highly multidisciplinary fields of Robotics and Automation.

The wide range of technical disciplines involved in Robotics and Automation is clearly manifested through the technical interest profile of the eight founding societies of the Council:

- Aerospace and Electronic Systems
- Circuits and Systems
- Components, Hybrids, and Manufacturing Technology
- Computers
- Control Systems
- Industrial Electronics
- Industry Applications
- Systems, Man, and Cybernetics

The rapid growth of interest in Robotics and Automation is apparent through several events: Through the rapid increase of attendance of the IEEE International Conference on Robotics and Automation sponsored by the Council in the last three years; the attendance in 1986 was nearly doubled from 1985. Through the geographical, international and institutional distribution of attendees at these conferences; in 1986 there were 132 attendees from outside the U.S., representing 19 countries, nearly 700 attendees from 36 states of the U.S., and participants from the academia. Through the large, nearly 8000 subscription, readership of the IEEE Journal of Robotics and Automation published by the Council, and through

the Journal's increasing volume; in 1987 the Journal goes from quarterly to bimonthly publication with a nearly 40% volume increase.

It is our hope that this Newsletter will promote the timely distribution of information on the growing and varied activities in the fields of Robotics and Automation, and will serve as a timely forum for communication on current Robotics and Automation research and development of common interest.

The Newsletter certainly reflects the gracious and competent work of the editor and his staff for which the Council expresses sincere appreciation. It is our expectation that the Newsletter editor in the future issues will increasingly benefit from the readers' timely communication, comments and technical contributions.

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Trivedi Named New Chair Of Computer Society TC

Dr. Mohan Trivedi, of the University of Tennessee, Knoxville, is the new Chair of the IEEE Computer Society's Technical Committee on Robotics. Trivedi succeeds Dr. Wesley Snyder of North Carolina State University, who has assumed the role of editor of this newsletter.

Trivedi's research interests are computer vision and robotics. Among his current activities is a project sponsored by the U.S. Department of

Energy on robotics systems for nuclear power plants. This work is being performed in cooperation with the Oak Ridge National Laboratory.

During his tenure as chairman, Trivedi said he hopes to expand the membership of the Robotics TC, which currently has 860 members.

"I would also like to see close cooperation with the Robotics and Automation Council", in which we sponsor specialized workshops on topics such as computers in robotics, robot programming languages, and computer architectures.
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Researchers Gather For Multisensor Workshop

W. E. Snyder

"Multisensor Integration" was the key topic of discussion as thirty leading robotics researchers gathered at Snowbird, Utah the first week of February for an NSF-sponsored workshop. While the skiing was undoubtably an attraction for several of the researchers, some of whom came early and left late, the workshop itself was two and a half very intensive days. Work began with coffee, doughnuts, and seminar lectures, followed by group discussions, lunch, more lectures, more discussions, and on through supper.

Howard Moraff, Program Director, Automation & Systems Integration Program, within the Engineering Directorate of the National Science Foundation, sponsored the event, and set its tone in his introductory remarks on Thursday morning. His objectives were: 1) To meet and discuss common interests, 2) To make recommendations to NSF on what types of research should be funded, and 3) To form a consensus on the research needs of the community.

Dr. Tom Henderson, faculty member of the Department of Computer Science at the University of Utah, organized the workshop. In collecting this group of people together Henderson hoped to provide an informal atmosphere in which groups of people could work in groups to define and delineate the discipline of "multisensor integration". Henderson noted that the field clearly has something to do with sensors, and something to do with using several sensors together in a complex system, but that the field wasn't really much more defined than that. The small groups that were formed were an attempt to provide some more definition.

Six speakers were invited to provide their views, and thereby to provoke discussion.

Some Highlights:

Kensall Wise from the Solid State Electronics Lab of the University of Michigan spoke on the nature of solid state sensors, and their future. He predicted the future "5th Generation Sensor" would be available by the 1990's. Such a sensor would include a sensor array (touch, force, chemistry, or pressure, etc.), a multiplexor, Analog-to-digital converter, Compensation via PROM, limited control, and a bus interface, all on the same chip.

Susan Hackwood, of the University of California discussed the use of color vision to detect defects in VLSI circuits.

Olivea Faugeras, of INRIA (France) presented a discussion of the problems in dealing with noise in mobile robots. He proposed to 1) explicitly represent uncertainty and 2) combine a large number of measurements. Faugeras then indicated the Kalman filter as one prototypical formalism in which to meet at least some of these objectives.

Ruzena Bajczy of the University of Pennsylvania discussed integration of vision and touch, noting that the motivation for most of the ideas in robotics comes from psychology, and that movement strategies are determined by expected features AND the geometry of the end effector.

John Hollerbach of MIT gave a presentation on biological sensory integration and illustrated the phenomenal precision of simple touch sensors in the human finger tip.

Steve Jacobson of the Mechanical Engineering Department of the University of Utah presented the properties and history of the Utah/MIT dextrous robot hand, as well as the use of touch and force sensors in the hand. He noted that a major problem in hand design is the need to avoid wires, since routing of wires takes precious room and radically reduces reliability. He emphasized the need for more experimental work among robotic theorists.

Jim Albus of the National Bureau of Standards presented the need for hierarchical structures of both sensors and actuators in a robot system.

Bob Bolles of SRI, Inc., emphasized the need for more use of sensors in robotics and expressed concern that more sensors were not currently used. He attributed this lack of sensor implementations to the "technique-based" research community: individual researchers are all interested in their own particular specialty, and there is not enough work on the systems issues.

Avi Kak of Purdue University stimulated debate by dividing the group into two debate teams to debate the issue of knowledge- based sensors. Unfortunately, both sides agreed: we need knowledge-based sensors, and we don't currently know how to do it well.

Mike Brady of Oxford University gave an impromptu illustration of the problems of developing knowledge-based representations in current expert systems.

Jim Yates of Alcoa led a discussion on the problems of getting industrial sponsorship and involvement in advanced automation research and development. The participants noted that the short-sighted one year return-on-investment philosophy practiced by many corporations (which were run by money managers and not by technical specialists) was inevitably leading to a complete takeover of advanced technology by Japanese firms.

The participants spent many hours in small group discussions. There were four such groups: 1) Sensors/signals, 2) Parallel/ multiprocessing, 3) Systems issues, and 4) CAD/CAM/AI. The reporters of the four groups presented their findings at the end of the workshop. A final report will be written and available from the NSF.

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Small Group Meetings To Accompany Conference Activities

In addition to the other activities which will occur at the Robotics and Automation conference in Raleigh this spring, several groups will hold their annual or semiannual meetings concurrently.

The Robotics and Automation Council will hold its semi-annual ADCOM meeting on the afternoon of Monday, March 30, at the Radisson Hotel, just across the hall from the afternoon tutorial sessions.

The ADCOM consists of 20 distinguished researchers in the field of robotics and automation, two from each of the participating IEEE societies. Unlike a society, within the IEEE, a council does not have individuals as members, but rather societies, and those societies are represented on the council by their respective ADCOM members.

The Council publishes the Journal of Robotics and Automation, as well as this newsletter, and sponsors the annual International Conference on Robotics and Automation. One of the principal activities at this meeting will the installation of a new president. Dr. A. Bejczy, will succeed Dr. Richard Paul as president of the ADCOM.

Robotics TC To Meet. The IEEE Computer Society Technical Committee on Robotics will hold its annual meeting on Wednesday, April 1. Dr. Mahon Trivedi, the new chair of the TC, has invited all current members and those interested in joining the TC to attend the meeting, whose time and place will be announced at registration.

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UTAH Range Image Database

Users of range images will be interested to learn of a range image database maintained by the University of Utah. Dr. Tom Henderson and Dr. Chuck Hansen of the University of Utah's Computer Science Department have collected a library of range images from several sources, stored in several formats, and these are now available to interested parties.

The library consists of 33 range images, requiring 5.2 Megabytes storage on magnetic tape. The images vary in complexity, from simple cubes and cylinders to the the irregular surfaces presented by a sculpture of a gargoyle. The smallest scale images are details from printed circuit boards. Larger images include bottles and jars.

Most of the images were scanned at the University of Utah using a Technical Arts 3-D White Scanner with 16 bit range resolution. Other images were scanned at N.C. State University (8 bit resolution), SRI (16 bit), and INRI (16 bit). A bust of Victor Hugo, which was scanned by revolving Victor's head in one degree increments, has been donated to the Utah library by ENST Paris.

The basic format for all images except the bust is an X,Y coordinate plane corresponding to rows and columns with the Z coordinate specifying altitude of the image above the X,Y plane. However, users should refer to the technical report listed below for details of the data formats.

Image formats, histories, and photographs are presented in technical report UUCS-86-113 of the University of Utah. For more information about the range image library, contact Dr. Tom Henderson of the University of Utah Computer Science Department, (801) 581-3601.

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16 Nations To Be Represented at Robotics Conference

Robotics and automation experts from at least 16 nations will meet in Raleigh this spring to present their latest research findings at the **4th International Conference on Robotics and Automation**. Robotics in space and autonomous robot vehicles are among the topics to be discussed at the 3-day conference, which will be held March 31- April 2 at the Raleigh Civic Center. The conference is sponsored by the Institute of Electrical and Electronic Engineers.

Researchers from the U.S.A. and overseas government and industrial organizations as well as university scholars will attend the annual conference, which last year attracted over 800 attendees.

Approximately one-third of the authors of papers to be presented at the Raleigh conference will come from outside the U.S. Participants are expected from most western European countries, Canada, Japan, China, India and Australia. Over 10 percent of the authors listed are affiliated with Japanese research institutions, an indication of the high level of interest in robotics and automation shown by Japanese government and industry. West Germany and France also have strong programs in robotics and automation research.

According to Dr. Arthur Sanderson of Carnegie-Mellon University, program chairman, participants in this year's conference will be impressed by the overall quality of the presentations and proceedings.

"We've had more papers submitted this year than ever before, but decided to limit the number accepted in order to keep the sessions and proceedings to a manageable size, " said Sanderson. "Over the past few years I have noticed both an increase in the level of interest in robotics and automation and in the sophistication of the papers. A few years ago there were many "naive" papers, descriptions of robot applications that were simple compared to the sophisticated systems of today."

According to Sanderson, the program committee made an effort to maintain a balance among the topics on the program and among the research organization represented on the program so that the conference will reflect the status of research in robotics and automation worldwide.

Although many of the papers presented at the conference are based on sophisticated mathematical and engineering concepts, Sanderson believes that many industrial managers interested in robotics would benefit from conference attendance.

"There is a lot of interest in planning and task level programs, which are important for the efficient implementation of robots. We also have a full track of papers related to automation."

Each of the seven tracks of the conference will hold four sessions each day. Approximately three hundred papers will be presented.

Dr. Sanderson said that no papers were submitted to the conference from the Soviet Union, although several were accepted from mainland China and Yugoslavia.

About 200 people are expected to attend one of the two tutorial sessions which will be offered March 30, the day before the main conference begins. Session I, intended for newcomers to the field of robotics, provides an overview of robotics kinematics, design, dynamics, and control. Session II, advanced topics in robotics, provides an overview of the issues involved in robot motion and task planning and the design of mobile robots. Organizers of the tutorial sessions are Dr. Chia Day of GMF Robotics Corp. and Dr. Scott Harmon of Robot Intelligence International.

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About Raleigh

Raleigh, North Carolina, the host city for this year's Robotics and Automation Conference, is a lovely city of approximately 200,000 people. In addition to being the state capital, Raleigh is home to 7 colleges and universities, including North Carolina State University. Duke University at Durham and the University of North Carolina at Chapel Hill are each about 25 miles from Raleigh, and the famed Research Triangle Park is located in the center of the triangle formed by the three cities. Raleigh is located in the center of the state, and is within easy driving distance of many historical and recreational attractions. For instance, the golf courses of Southern Pines and Pinehurst are only an hour from Raleigh. The Cape Hatteras National Seashore is about a four hour drive.

While early spring weather is unpredictable (Raleigh's annual snowfall occasionally comes in March), daytime temperatures in the high 70's and low 80's are common, while nights are cool.

The Raleigh Civic Center and the Radisson are located in downtown Raleigh. A two-mile stretch of Fayetteville Street, the central street, has been converted to a pedestrian mall, which stretches from the Civic Center to the new legislative building. The N.C. Museum of Natural History and the N.C. History Museum are located near the old Capitol, which still bears the scars from General Sherman's visit to Raleigh in 1864. Works of local artists are displayed in the Municipal Building and Raleigh Contemporary Galleries during business hours. The Spectator Magazine is a good source of information about area dining and entertainment.

The State Legislature is in session from January through June this year, so conferees will encounter North Carolina politicians and lobbyists as well as state employees and downtown office workers on the Fayetteville Street Mall and at downtown restaurants.

Lunch places downtown run the gamut from the Radisson to Hardees. Popular places within walking distance of the Civic Center include the cafeteria upstairs at Hudson-Belks Department store, Irregardless Off the Mall, Est Est Est, and Clyde Coopers Barbeque. Of these, only Est Est Est serve dinner. Several other restaurants are planning to open this spring downtown.

For dinner, the Triangle offers some truly wonderful places in addition to a horde of chains and fast food joints. The Angus Barn is renowned both for its prime steaks and roast beef and as a hangout for well-heeled "good old boys". Sisters Garden of Eating and the Velvet Cloak offer fine continental cuisine. Hunan Palace and Aloha are good Chinese restaurants. Irregardless, on Morgan Street downtown, has a number of vegetarian

entrees. In Chapel Hill try La Residence for eclectic French cuisine or Slug's At The Pines for seafood and beef. At Durham's Brightleaf Square, a tobacco warehouse that has been converted to trendy shops and restaurants, the fare includes new American cuisine at Apples or the food and drink of an English pub at Duke of York Restaurant & Pub. Ask the locals for more names and prices.

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Governor To Speak
At Conference

The Honorable James Martin, Governor of North Carolina, will give the welcoming remarks at the Robotics and Automation Conference. The governor will address the first plenary session of the conference, at 2 p.m. on Tuesday, March 31. His remarks will precede the lecture by Professor Raj Reddy, Director of the Robotics Institute at Carnegie-Mellon University.

Martin, a Republican, has indicated a desire to both continue and extend the tradition of research support established by his predecessors. That tradition led to the establishment of the well-known Research Triangle Park, located between the cities of Raleigh, Durham, and Chapel Hill, and home of many high-tech research and development companies.

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Conference Exhibits

The 1987 Robotics and Automation Conference will feature an attraction not found in past conferences. This year, for the first time, exhibitors from various industries and educational institutions will be presenting displays for attendees of the conference.

The exhibits will be in the exhibit hall of the Raleigh Civic Center and will run Tuesday, Wednesday, and Thursday, March 31 to April 2. Between twenty and thirty exhibits are planned, with fifteen spaces already reserved. Since coffee services for the conference will be located in the conference hall with the exhibits, attendees will have several convenient viewing times each day in the form of scheduled coffee breaks.

Anticipating the large academic contingent at the conference, numerous publishing concerns have already reserved exhibit space. Among these are Prentice Hall, Marcel Dekker, Springer-Verlag, Addison-Wesley and McGraw Hill.

Manufacturing and research groups from all over the U.S. will also be exhibiting, on a wide variety of topics. In particular, artificial intelligence, computer vision, and various PC-based robotics tools will be subjects of interest. The following is a list of exhibitors who have already reserved space, which indicates what conference attendees can expect to see: Hewlett-Packard, Symbolics, Carnegie Group, New Port Corporation, Definicon, N.C. State University AI Laboratory, Silma, C. Abaci, and the publishers listed above.

Several IEEE members are contributing efforts to organize the exhibits. They are Dr. Ed Fisher and Mr. Bob Edwards of N.C. State University and Mr. Harry Hayman, the official coordinator of the conference. Communication Unlimited, a computer vision company located in Raleigh, is also donating considerable time.

To reserve one of the few remaining spaces, interested companies should contact Mark Yarborough, Communication Unlimited, 4605 Western Blvd., Raleigh, NC 27606, (919) 851-1368.

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R & A Local Arrangements
Committee Plans Social Program

Live theatre and standup comedy are among the

evening diversions which await attendees at the Robotics and Automation Conference in Raleigh. The North Carolina Theatre will present *Fiddler on the Roof* April 1-5. Performances are at Memorial Auditorium, which is within walking distance of the Radisson Plaza Hotel. A few blocks away is Charlie Goodnight's Comedy Club, which offers two performances nightly, each with at least three different entertainers.

The Conference reception on Tuesday evening will feature a sampling of traditional, "down-home" North Carolina barbeque, cole slaw, and hush puppies.

A walking tour of the Capitol District is being planned for Wednesday, April 1, for those who have a free afternoon. This will include guided tours of the old N.C. Capitol, and Mordecai Historic Park, which includes a 19th century plantation house and gardens, the birthplace of President Andrew Johnson, and an extensive garden. Participants will also stroll through Historic Oakwood, a neighborhood of elegant Victorian homes, including the N.C. Governor's mansion. The cost will be about $5.00/person.

Two day excursions are planned for spouses and families who come to Raleigh: the North Carolina Zoo in Asheboro and Tryon Palace in New Bern.

Tryon Palace, the residence of North Carolina's colonial governor, is the centerpiece of a fourteen acre complex of historic buildings and beautiful English gardens. It has been elegantly restored to its appearance in the early 1770's and furnished with authentic English and American antiques. The cost of $35.00 per person covers transportation and admission to Tryon Palace and Gardens, and two other beautiful landmarks, the John Wright Stanly House and the Stevenson House.

At the North Carolina Zoo, zebras, ostriches, giraffes, elephants, lions, and rhinoceros roam through the seven natural habitats recreated for the " "Africa" section. A free flight aviary features 150 species of birds and luxuriant tropical plants. The cost is $19 per person, which includes transportation and admission.

A one-day golf package at the Mid Pines Resort at Southern Pines is offered on Friday, April 3, for those who can linger in North Carolina. The cost

is $57 per person, including transportation, green and cart fees.

Conference attendees may register for the social program when they arrive in Raleigh. A minimum of 30 participants will be required for the bus excursions to be offered at these prices.

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Positions Available

The School of Electrical Engineering at Purdue University invites applications for tenure-track faculty positions from qualified individuals having a strong commitment to teaching and research. Qualifications include an outstanding academic record, a significant involvement with a truly contributive research activity, and a doctorate in electrical or computer engineering. Areas of research specialization which are of particular interest are computers, robotics, and microelectronics.

Resumes should be directed to: Head, School of Electrical Engineering, Purdue University, West Lafayette, IN 47907.

Immigration status of non-U.S. citizens **must** be stated in application. Purdue University is an Equal Opportunity/Affirmative Action employer.

Mechanical Engineering McGill Research Centre For Intelligent Machines. Associate or Full Professor in the area of Robotics. The Faculty of Engineering has considerable strength in Vision and Robotics, and a well-equipped laboratory. The ideal candidate would have a research interest in manipulator design at the theoretical or conceptual stage, and would interact with researchers in AI and in physiology or biomechanics. McGill is a node of the AIR (Artificial Intelligence and Robotics) program of the Canadian Institute for Advanced Research. A candidate for this position would also be expected to be a strong candidate for a Fellowship in the AIR program; an appointment to a CIAR Fellow-

ship offers the opportunity to concentrate mainly on research. A Ph.D is required, with a strong publication record. Replies to: Professor P.R. Belanger, Dean, Faculty of Engineering, McGill University, 817 Sherbrooke Street West, Montreal, Quebec, H3A 2K6. (In the first instance, this offer is addressed to Canadian citizens and landed immigrants, according to Canadian immigration rules.)

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CALENDAR

Built-in Self-Test Workshop (IEEE Test Technology Committee), March 9-11. Kiawah Island, Charleston, SC. Contact Richard Sedmak, Self-Test Services, 6 Lindenwold Terrace, Ambler, PA 19002. (215) 628-9700.

Robot Safety Workshop, March 11-12. Los Angeles Airport Hilton, Los Angeles, CA. Contact Steve Trombino, RIA, 900 Victors Way, P.O. Box 3724, Ann Arbor, MI 48106. (313) 994-6088.

20th Annual Simulation Symposium (ACM, IMACS, SCS), March 11- 13. Tampa, FL. Contact James Gantt, 5986 Dana Dr., Norcross, GA 30093. (404) 894-3107.

1987 13th Annual Northeast Bioengineering Conference (EMB), March 12-13. Philadelphia, PA. Contact Kenneth Foster, Conference Chairman, Univ. of Pennsylvania School of Engineering and Applied Science, Dept. of Bioengineering, Philadelphia, PA 19104-6392 (215) 898-8501.

19th Southeastern Symposium on System Theory (Piedmont), March 15-17. Clemson Univ., Clemson, SC. Contact E.G. Baxa Jr., General Chariman, SST-87, E&CE Dept., Clemson Univ., Clemson, SC 29634-0915.

Technology and Fabrication Exhibition-Glassex, March 15-18. National Exhibition Centre, Birmingham, England. Contact British Information Services, 845 Third Ave., New York, NY 10022. (212) 752-8400.

Tutorial Week Orlando 87, March 16-20. Kissimmee, Fl. Contact Ratan Kumar Guha, Computer Science Dept. Univ. of Central Florida, Orlando, FL 32816. (305) 275-2341.

Thirteenth Annual Computer Fair, March 18-19. Univ. of Washington, Seattle, WA. Contact Thomas Bennett, U.W. Academic Computing Services, 3737 Brooklyn Ave. Northeast, Seattle, WA 98105. (206) 543-5728.

NCGA Computer Graphics '87, March 22-26. Philadelphia Civic Center, Philadelphia, PA. Contact NCGA, 2722 Merrilee Dr., Suite 200, Fairfax, VA 22031. (800) 225-NCGA.

Advanced Research in VLSI-New Technologies for New Architectures, March 23-25. Stanford Univ., Stanford, CA. Contact Meeting Planning Assoc., 883 Santa Cruz Ave., Suite 30 Menlo Park, CA 94025. (415) 326-7781.

Advances in Semiconductors and Semiconductor Structures, March 23-27. Marriott's Bay Point Resort, Bay Point, FL. Contact John Powers, SPIE Press Relations, P.O. Box 10, Bellingham, WA 98722-0010. (206) 676-3290.

1987 IEEE VLSI Test Workshop, March 24-25. Atlantic City, NJ. Contact Wesley E. Radcliffe, IBM East Fishkill, Dept. 277, Bldg. 321-5E1, Hopewell Junction, NY 12533. (914) 894-4346.

Southcon '87 (Reg. 3, Atlanta and Fla. Secs.), March 24-26. Georgia World Congress Center, Atlanta, GA. Contact Dale Litherland Electronic Conventions Inc., 8110 Airport Blvd., Los Angeles, CA 90045 (213) 772-2965.

American National Standards Institute's 1987 Public Conference, March 25. Marriott Crystal Gateway Hotel, Arlington, VA. Contact Cindy Swanteck, American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018. (212) 642-4922.

1987 International Conference on Robotics and Automation (RA), March 30-April 2. Radisson Hotel, Raleigh, NC. Contact Arthur Sanderson, Program Chairman, Carnegie-Mellon Univ., Robotics Institute, Pittsburgh, PA 15213. (412) 268-2590.

IEEE Infocom 87, Sixth Annual Joint Conference of the IEEE Computer and Communications Societies: Global Networks-Concept to Realization, March 30-April 2. San Francisco, CA. Contact IEEE Infocom 87, 1730 Massachusetts Ave. NW, Washington, D.C. 20036-1903. (202) 371-0101; telex 7108250437 IEEECOMPSO.

Ninth IEEE International Conference on Software Engineering (ACM), March 30-April 2. Monterey, CA. Contact William Riddle, Software Design and Analysis,

1760 Bear Mountain Dr., Boulder, CO 80303. (303) 499-4782.

Measurement and Inspection Exhibition-Inspex, March 30-April 2. National Exhibition Centre, Birmingham, England. Contact British Information Services, 845 Third Ave., New York, NY 10022. (212) 752-8400.

Fifteenth Annual Interface '87 Conference and Exposition, March 30- April 2. Las Vegas, NV. Contact Keith F. Westerman, Interface Group Inc., 300 First Ave., Needham, MA 02194. (617) 449-6600.

Analysis and Interpretation of Images and Image Sequences, March 30-April 3. International Congress Center, Berlin, FRG. Three-part seminar covering: knowledge based image analysis, analysis and interpretation of image sequences (fundamentals); and analysis and interpretation of image sequences (quantitative aspects). For information contact: BECEEP, Ausstellungs-Messe- Kongress GmbH, Messedamm 22, D-1000 Berlin 19, FRG. (030) 30 38-1.

Fourth International Symposium on Optical and Optoelectronic Applied Science and Engineering, March 30-April 3. Netherlands Congress Centre, The Hague, The Netherlands. Coverage includes: high-power lasers; optical waveguides; fibre optic sensors; optical microlithography for IC fabrication and inspection; optical components and systems; advances in image processing; scanning optical imaging, passive and active infrared systems; novel optoelectronic devices. For information contact: Beatrice Denoyel, Association Nationale de la Recherche Technique, 101 Avenue Raymond Poincare, 75116 Paris, France. (331) 4-501-7227.

International Conference on Acoustics, Speech, and Signal Processing-ICASSP '87 (ASSP), April 6-9. Registry Hotel, Dallas, TX. Contact Panos Papamichalis, Conference Chairman, Texas Instruments Inc., P.O. Box 1443, MS 6400, Houston, TX 77001. (713) 879-2374.

CADD '87-International Conference on Computer-Aided Drafting, Design, and Manufacturing Technology, April 21-25. Beijing, China. Contact Automation Technology Institute, P.O. Box 242, Pebble Beach, CA 93953. (408) 624-5892.

Computer Analysis of Images and Patterns, April 22-24. Palast Hotel, Berlin, GDR. For information contact CAIP'87 Conference Secretariat, KDT, Prasidium, WGMA, Koll. Muller, Clara Zetkin Strasse 115/117, 1086 Berlin, German Democratic Republic.

18th Annual Pittsburgh Conference on Modeling and Simulation, April 23-24. Univ. of Pittsburgh, Pittsburgh, PA. Contact Marlin Mickle, Conference Co-Chairman, Univ. of Pittsburgh, School of Engineering, Pittsburgh, PA 15261. (412) 624-4141.

1987 Annual Systems Conference, April 26-29. Galt House, Louisville, KY. Contact Richard McCaffrey, ASM, 24587 Bagley Rd., Cleveland, OH 44138. (216) 243-6900

Robots 11/17th International Symposium on Industrial Robots, April 26-30. Chicago, IL. Conference presentations will cover robotic applications, research and development, human factor considerations, and robotic education. Contact: SME, One SME Dr., P.O. Box 930, Dearborn MI 48121.

IMTC '87 Instrumentation and Measurement Technology Conference (IM, Boston, Sec.), April 27-29. Sheraton-Boston Hotel, Boston, MA. Contact Robert Myers, 1700 Westwood Blvd., No. 101, Los Angeles, CA 90024. (213) 475-4571.

International Symposium on Defect Recognition and Image Processing in III-V Compounds, April 27-29. Monterey, CA. For information contact Continuing Education in Engineering, University Extension, University of California, 2223 Fulton St., Berkeley, CA 94720.

International Service Robot Conference-ISRC '87 April 27-30. McCormick Place, Chicago, IL. NSRA and RIA are cosponsors of the conference being held in conjunction with ROBOTS 11. The theme is "Robots in the Service of Humans". Presentations slated include service robots in education, health care, space exploration, and household applications. The conference portion will have industry experts discussing artificial intelligence, hardware, and software development, and sensors. For more information contact Jeff Burnstein (313) 994-6088.

1987 IEEE International Symposium on Circuits and Systems, May 4-7. Dunfey City Line Hotel, Philadelphia, PA. Contact S.D. Bedrossian, Conference Chairman, Electrical Engineering, Univ. of Pennsylvania, Philadelphia, PA 19104. (215) 898-8518.

1987 Custom Integrated Circuits Conference-CICC '87 (ED, SSC), May 4-7. Portland Hilton Hotel, Portland, OR. Contact Laura Silzars, Convention Coordinating, 6900 S.W. Canyon Dr., Portland, OR 97225. (503) 292-6347.

1987 IEEE IAS Textile Industry Conference (IA), May 5-7. Ravinia Hyatt Regency Hotel, Atlanta, GA. Contact Dave Heath, Micro Switch, 6 W. Druid Hills Dr., NE, Atlanta, GA 30329. (404) 982-2564.

Compeuro 87, International Conference on VLSI and Computers, May 11-15. Hamburg, West Germany. Contact W.E. Proebster, IBM Germany, Dept. 3280, Sci. Tech., Schoenaichen St. 220, Boeblingen

7030, West Germany.

International Symposium on Automotive Microelectronics Vehicle Management Systems and Computer Aided Testing, May 11-15. Florence, Italy. Contact John Soliman, Chairman, Automotive Automation Ltd., 42 Lloyd Park Ave., Croydon CRO 5SB, England. 01-680-8659.

IEEE Workstation Technology and Systems Workshop, May 12-13. Cherry Hill, New Jersey. Contact Ralph J. Preiss, 12 Colburn Dr., Poughkeepsie, NY 12603.

Computer Aided Laboratories Symposium and Exhibition, May 12-14. Sheraton O'Hare, Chicage, IL. Contact Robert Zutkis, Infoscience Services Inc., 2970 Maria Ave., P.O. Box 153, Northbrook, IL 60065-0153. (312) 291-9161.

AutoMan '87, May 12-15. National Exhibition Centre, Birmingham, UK. Fourth European automated manufacturing exhibition and conference, emphasizing machine intelligence and robotics. Contact Cahners Exhibitions Ltd, Chatsworth House, 59 London Rd., Twickenham, Middx TW1 3SZ, UK. Tel: 01-891 5051.

Third International Symposium on VLSI Technology, Systems, and Applications, May 13-15. Taipei, Taiwan. Contact Ben M. Y. Hsiao, IBM Corp., Dept. D18, Bldg. 707, P.O. Box 390, Poughkeepsie, NY 12602 or Morris Chang, ITRI, No. 1, Jen Ai Rd., Sec. 2, Taipei, Taiwan.

Conference and Exhibition on Computing and Automation in the Sciences, May 13-15. RAI Congress Centre, Amsterdam. The Netherlands. Contact Keith Foley, Elsevier Science Publishers, P.O. Box 330, 1000 AH Amsterdam, The Netherlands. 020 5862-828.

Avignon '87-7th International Workshop on Expert Systems and their Applications, May 13-15. Avignon, France. Contact Jean-Claude Rault, Avignon '87, BP 45, 92193 Meudon Cedex, France. (331) 40-264528.

Robot-Programming Workshop, May 14-15. McGill University, Montreal, Quebec. The objective of this workshop is to make the attendants familiar with robot-programming techniques, emphasis being placed on the RCCL Programming System, especially for potential users and implementers. Contact Lorna McFadden, Dept. of Mining and Metallurgical Engineering, McGill Univ., 3480 University St., Montreal, Quebec, Canada H3A 2A7.

World Productivity Forum, May 17-20. Washington, D.C. Contact Institute of Industrial Engineers, Conference Coordinator, 25 Technology Park/Atlanta, Nor-cross, GA 30092. (414) 449-0460.

SPIE-1987 Technical Symposium Southeast on Optics and Optoelectronics/Exhibit, May 17-22. Peabody Orlando Hotel, Orlando, FL. Contact SPIE, P.O. Box 10, Bellingham, WA 98227-0010. (206) 676-3290.

Control and Instrumentation Exhibition and Conference, May 18-21. Earls Court, London, England. Contact British Information Services, 845 Third Ave., New York, NY 10022. (212) 752-8400.

Naecon '87 Technical Program and Exhibition (AES), May 18-22. Dayton Convention Center, Dayton, OH. Contact Mary Terbay, National Aerospace & Electronics Conference, 110 E. Monument Ave., Dayton, OH 45402. (513) 254-5377.

MARI 87 (Intelligent Networks and Machines), May 18-22. International Conference Center, La Villette, Paris, France. Comprises two symposia-Cognitive 87 and Image Electronique-along with specialized courses, an industrial forum and an exhibition. Topics include AI, vision, robotics, cognitive sciences, neurosciences and intelligent networks. For more information contact MARI Secretariat, Isabelle Chardonnet, CES-TA, 1 rue Descartes, 75005 Paris, France. Tel: (331) 46-32-32-98.

CG International 87, Fifth International Conference on Computer Graphics in Japan (CGS), May 25-28. Karuizawa, Nagano Prefecture, Japan. Contact Tosiyasu L. Kunii, Dept. of Information Science, Faculty of Science, University of Tokyo, Hongo, Tokyo 113, Japan. Tel: 81 (03) 812-2111, ext. 4116.

1987 International Symposium on Multiple-Valued Logic, May 26- 28. Boston, MA. Contact Dan Simovici, Dept. of Mathematics and Computer Science, University of Massachusetts, Boston, MA 02125. (617) 929-7966.

IFIP Workshop on CAD Engines, June 1-2. Kakaishinlou, Kainkan, Japan. Contact Tatsuo Ohtuski, Waseda University, Dept. of Elec. and Comm., School of Science and Engineering, 3-4-2 Okubo, Shinjuku, Tokyo 160, Japan. Tel. 81 (03) 209-3211.

Eleventh GRETSI Symposium on Signal and Image Processing, June 1-5. Nice, France. Symposium designed to bring together specialists in signal and image processing. Approaches imaging via modelling, analysis, and decision, coding and compression, the impact of numerical methods and computer science etc. For more information contact Secretariat du Colloque GRETSI, 7 Chemin des Presses, BP 85, 06801 Cagnes-sur-Mer Cedex, France. Tel: (93) 20- 01-40.

Westex-87, Second Western Expert Systems

Conference, June 2-4. Anaheim, CA. Contact Westex 87, P.O. Box 2111, Fullerton, CA 92633-0111.

5th Scandinavian Conference on Image Analysis. June 2-5. Saltsjobaden, Sweden. Papers will present new results and basic investigations of image analysis in computer vision, image processing, pattern recognition and perception. Contact Dr. Torleiv Orhaug, National Defence Research Institute, PO Box 1165, S-581 11 Linkoping, Sweden.

14th International Symposium on Computer Architecture, June 2-5. Pittsburgh, PA. Contact Zary Segall, Computer Science Dept., Carnegie-Mellon University, Pittsburgh, PA 15213. (412) 268-3736.

ICCV '87, June 8-11. London, UK. First international conference on computer vision, including invited talks on human perception and biological vision systems as well as contributed papers. Contact ICCV '87, c/o IEEE Computer Society, 1730 Massachusetts Avenue, NW, Washington, DC. 20036-1903.

1987 University and Government and Industry Conference (CHMT, ED, Roch. Sec.), June 9-11. Hilton Inn on the Campus, Rochester Institute of Technology, Rochester, NY. Contact Lynn Fuller, Rochester Institute of Technology, Rochester, NY 14692. (716) 475-2035.

IEEE Workshop on Software Technology Transfer, June 11-13. Santa Fe, NM. Contact Charles Richter, MCC, Software Tech. Prog., 9430 Research Blvd., Austin, TX 78759.

NCC-87, National Computer Conference, (ACM, AFIPS, DPMA, SCS), June 15-18. Chicago, IL. Contact AFIPS, 1899 Preston White Dr., Reston, VA 22091. (703) 620-8900.

1987 IEEE Annual Meeting, June 18-19. New York Marriott Marquis, New York, NY. Contact Betty Stillman, IEEE Corporate Services, 345 E. 47th St., New York, NY 10017-2394 (212)705-7757.

AIPC-8, June 23-25. Chicago, IL. Eighth international conference on automated inspection and product control, covering inspection systems, sensors, AI, mechanical considerations, etc. Contact Dr. Keith McKee, Manufacturing Productivity Center, IIT Research Institute, 10 West 35th St., Chicago, IL 60616. (312) 567-4800.

Second International Conference on Computer Applications, June 24-26. Beijing, China. Contact Tse-yun Feng, Penn State University, Electrical Engineering East Bldg., University Park, PA 16802 or Oscar N. Garcia, Dept. of Electrical Engineering and Computer Science, Rm T-637, George Washington University, 801 22nd St. NW, Washington, D.C. 20052.

(202) 676-7175.

DAC-87, 24th ACM/IEEE Design Automation Conference, June 28- July 1. Miami Beach, FL. Contact Design Automation Conference, P.O. Pistilli, MP Associates, 7366 Old Mill Trail, Boulder, CO 80301. (303) 530-4562.

Conference on Computer Assurance-Compass '87, July 6-10. Washington, D.C. Contact M. Frank Houston, Program Chairman, IEEE Compass '87, P.O. Box 5314, Rockville, MD 20851. (301) 443-5020.

ACM Siggraph '87, July 27-31. 14th annual conference and exhibition on computer graphics and interactive techniques sponsored by the ACM special interest group on computer graphics. For information contact Smith, Bucklin and Associates, Inc., 111 E. Wacker Drive, Chicago, IL 60601. (312) 644-6610.

Second International Conference on Applications of Artificial Intelligence in Engineering, August 4-7. Boston, MA. Coverage includes knowledge-based systems, knowledge representations, learning, natural language applications, cognitive modelling, graphical interfaces, knowledge-based simulation and model-based solving. Contact Computational Mechanics Institute, Wessex Institute of Technology, 52 Henstead Rd., Southampton SOI 2DD, UK. (0703) 221398.

IEEE Workshop on Visual Languages, August 19-21. Linkoping, Sweden. Contact, Erland Jungert, FFV Elektronik AB, Agatan 22, S-582 22 Linkoping, Sweden.

Tencon '87-Consumer and Electronics and Applications Conference (Reg. 10, Korea Sec.), August 26-28. Sheraton Walker Hill, Seoul, Korea. Contact Seung Taik Yang, Conference Chairman, Electronics and Telecommunications Research Institute, P.O. Box 8, Dae Dog danji Chung Nam, Korea 300. (042) 822-4455.

European Conference on Speech Technology, Sept. 2-4. Edinburgh, Scotland. Contact Secretariat, European Conference on Speech Technology, CEP Consultants Ltd, 26 Albany St., Edinburgh EH1 3QH, UK.

1987 International Conference on Digital Signal Processing, Sept. 7-10. Florence, Italy. Covers advances in the theory and techniques of digital signal and image processing and digital filtering. Contact Prof. Vito Cappellini, Instituto di Ricerca Sulle Onde, Elettromagnetiche, Consiglio Nazionale delle Ricerche, Via Panciatichi, 50127 Firenze, Italy.

International Conference on Systems Engineering (Dayton Sec.), Sept. 9-11. Wright State Univ., Dayton, OH. Contact B.A. Shenoi, Electrical Systems Engineering, Wright State Univ., Dayton, OH 45435. (513) 873-3527.

IEEE-EURASIP 5th Workshop on Multidimensional Signal Processing, Sept. 14-16. Leeuwenhorst Congress Center, Noordwijkerhout, The Netherlands. Contact Mrs. Y. Smits, Dept. of Electrical Engineering, Delft University of Technology, P.O. Box 5031, 2600 GA Delft, The Netherlands.

4th International Conference in Image Analysis and Processing, Sept. 23-25. Cefalu, Sicily, Italy. Contact Prof. Vito di Gesu, Dipartimento di Matematica e Applicazioni, Universita di Palermo, 90123 Palermo, Italy.

BPRA 4th International Conference on Pattern Recognition, March 28- 30, 1988. Queens College, Cambridge, England. For information contact Dr. J. Kittler, Dept. Electronic and Electrical Engineering, University of Surrey, Guildford GU2 5XH, England.

IAPR 9th International Conference on Pattern Recognition, October 17- 20, 1988. Beijing, China. For information contact 9ICPR Secretariat, Chinese Association of Automation, P.O. Box 2728, Beijing, China.

19th International Symposium and Exposition on Robots. 1988. Sydney, Australia. The symposium will be held as part of Australia's bicentennial celebration. Papers presented will discuss the complex applications and implications of robot technology in modern society. The exposition will display robots at work in industry, the home, and educational institutions. Contact Dr. Michael Kassler, The Australian Robot Association, 9 Queens Ave., McMahons Pt., Sydney 2060, Australia. Tel: (02) 922-5026.

1987 IEEE INTERNATIONAL CONFERENCE ON

ROBOTICS AND AUTOMATION

March 30-April 3, 1987
Radisson Hotel and Raleigh Civic Center
Raleigh, North Carolina

Registration Form
1987 IEEE International Conference on
Robotics and Automation
March 30-April 3, 1987

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

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North Carolina State Univ.
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Box 7401
Raleigh, NC 27695-7401

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☐ Please send me a full advance program

Please register me as follows (Circle appropriate fee):

	Member fee	Non-member fee	Student fee
☐ Conference	$160	$200	$ 50
☐ One Tutorial	$ 75	$100	$ 75
☐ Two Tutorials	$135	$170	$135
☐ Conference and One Tutorial	$235	$300	$125
☐ Conference and Two Tutorials	$295	$370	$185
☐ Workshop	$ 60	$ 75	$ 60
☐ Conference and Workshop	$220	$270	$110
☐ Conference, Workshop & one Tutorial	$295	$375	$185
☐ Conference, Workshop & two Tutorials	$355	$445	$245

If you are attending the tutorials please list the tutorial numbers on the line below (You may attend only two tutorials—one morning and one afternoon):

☐ Payment Enclosed

For Registration after March 20, 1987 add $25 late fee.

The tutorials and workshop includes coffee breaks and notes.

Conference registrations 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) is $50. 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.

Request for refunds (less $15 handling fee) must be received in writing prior to March 20, 1987.

Late registration will be accepted beginning Sunday, March 29, 1987 at the Radisson Hotel at 4:00 PM.

1987 IEEE International Conference on
Robotics and Automation
March 30-April 3, 1987

Guest Room Registration Request

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Arrival Date and time

Departure Date

A block of rooms for this conference is reserved until March 2, 1987. Reservations received after this date will be confirmed on an availability basis.

Note: Rooms will be held until 6 PM on specified arrival day, unless otherwise noted. Should you wish to guarantee your accommodation for late arrival supply the following information:

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Forward this form to the hotel of your choice:

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The Radisson adjoins the Raleigh Conference Center. The Holiday Inn is in walking distance of the Raleigh Conference Center. Shuttle bus service will be provided from the Mission Valley Inn to Raleigh Conference Center.