Newsletter of the IEEE Robotics & Automation Society

IEEE ROBOTICS AND AUTOMATION

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In This Issue

THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.
IEEE

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

Call For Videos

The 1991 IEEE International Conference on Robotics and Automation plans to issue video proceedings. Videos are hereby solicited in all aspects of experimental work and demonstrations in robotics and automation. Accepted videos will be edited and released through IEEE on VHS tapes. Authors interested in submitting videos for review should meet the following criteria:

1. Video presentations are limited to 3 minutes. An audio presentation should accompany the video recording.

2. A write-up, not exceeding two pages, describing the video tape should be submitted with the video recording.

3. Video recordings will be accepted that are either intended to be used at the 1991 Robotics and Automation Conference presentations or present experimental data not connected with the conference papers. All accepted tapes will be shown in a **Video Session.**

4. It is recommended that the tapes be recorded on 3/4" U-matic video or super grade high fidelity super VHS tape. For better quality the following recording formats may be used: 16mm film, 35mm film, Betacam, or 1" type c video.

Submissions: One copy should be sent by October 15, 1990 to:
Prof. T.J. Tarn, Program Committee Chairman
Campus Box 1040
Washington University
St. Louis, MO 63130
FAX: (314)726-4434, Tel: (314) 889-6037
e-mail:tarn@wurobot.wustl.edu
Authors will be notified of acceptance by January 15, 1991.

From the President

Arthur C. Sanderson
Rensselaer Polytechnic Institute

I recently had the opportunity to attend the inaugural meeting of the Tokyo Chapter of the Society. The meeting was held at the University of Tokyo and included participation from both university and industry leaders in the robotics and automation community. I want to express my appreciation to both the chapter and the university for their hospitality in hosting this first meeting as well as several international visitors.

I believe that chapter activities perform an important function for the society, and provide a regional focus which helps to strengthen local interactions, the exchange of information, and the professional community.

The **Tokyo Robotics and Automation Chapter** is a good example of a group which will complement its own activities by close cooperation with Japanese national organizations in robotics and automation as well as other international professional societies. In another example of joint cooperation, one proposed chapter in Region IX Latin America, will be a joint IEEE chapter of both the Robotics and Automation Society and the Control Society.

Our Vice President for Membership and Chapter Activities, **Harry Stephanou,** is actively pursuing many of these new initiatives. He will attend the Chapter's Congress, a biannual meeting with representation from all the international regions and sections of IEEE, to be held in Toronto in early October of this year. Some of the topics to be discussed at this conference include better communications among chapters within and between societies in IEEE, and improved communication of technical activities and information among chapters and societies.

Cooperation is an increasingly important theme for many of our society activities, especially for those with international dimensions. These cooperative activities provide both a base for member participation in the society as well as a means to broaden and strengthen technical dimensions of the society. Conferences, workshops and symposia are developing wide participation and an increasingly international scope.

In 1990, we cosponsored the **3rd IEEE Workshop on Micro Electro Mechanical Systems** and we are actively participating in discussions to cosponsor a Transactions publication in this rapidly growing area. Also this year, we have cooperated in the **Intelligent Robot Symposium, IROS '90,** which was held in Tsuchiura, Japan, in July, and with the **5th IEEE International Symposium on Intelligent Control** which will take place in Philadelphia in September.

In 1991, we will again be a cosponsor of the Micro Electro Mechanical Systems Workshop, and cooperate in the IROS '91 conference to be held in Yokohama, Japan, in the IEEE International Symposium on Intelligent Control to be held in Glasgow, Scotland, in the Fall of 1991, the International Symposium on Intelligent Robotics to be held in Bangalore, India, in January, and with the International Conference on Advanced Robotics to be held in Pisa, Italy, in June of 1991. We have already begun discussions to cosponsor the IROS '92 conference to be held in July 1992, at a site to be selected in the United States. As a cosponsor of IROS '92 in the U. S., we hope to provide an additional forum for exchange of technical information during a year when the IEEE International Conference on Robotics and Automation will take place in Europe.

The technical breadth, the geographical distribution, and the strong participation in all of these activities are all indicative of the central role which robotics and automation has as an emerging technology which is fundamental to the development of new generations of intelligent machines. As President during the start-up phase of the new society, I have tried to encourage those initiatives and activities which will foster technical communication, interchange, and education.

Norman Caplan is taking over as Society President in January. In his role at NSF, he has worked closely with the international research community for more than twenty years and brings excellent experience and insight to this position. I want to wish him the best of luck with these ongoing challenges.

I would like to sincerely thank all of the society members, officers and IEEE staff with whom I have had the pleasure of interacting over the past two years. The IEEE is a unique organization which functions through the responsibility and enthusiasm of its many volunteer participants. I have been gratified by the cooperation which I have received, and I would encourage all members of the society to take a more active role in organization and management of our society and chapter activities.

ACS, August 30, 1990

R&A Society News

Call for AdCom Nominations

The Robotics and Automation Society currently has an 18-member Administrative Committee (AdCom) rotating on three-year terms. Beginning next year, we need to fill six vacant AdCom positions by election in early February. Professor Y. C. Ho, Chairman of the Nominating Committee, is working closely with Professor A. C. Sanderson, President of the Society, to come up with a slate of candidates for the six vacant slots on the AdCom .

I strongly urge anyone who is interested in the affairs of the Society to volunteer himself/herself. There are two channels for nomination for election to the AdCom.

As stated in the Society Bylaws, anyone can be nominated with petitions signed by twenty-five (25) or more members of the R&A Society. These petitions must be received by Professor Ho (Address: Harvard University, Pierce Hall, Room G12i,29 Oxford Street, Cambridge, MA 02138) or me (Address: School of Electrical Engineering, Purdue University, West Lafayette, IN 47907) by **November 15.**

It is also possible to be nominated through the Nominating Committee. Just send Professor Ho your updated short bio, resume and your areas of expertise. Although the Nominating Committee may not be able to nominate everyone who volunteers to the AdCom, the Society has many appointed positions that may be able to use your talent and service.

George Lee, Secretary
IEEE R&A Society

Hayman Honored for Service to Society

Harry Hayman, who has served as the treasurer for the IEEE Conference on Robotics and Automation since 1985, was presented with a plaque by 1990 Conference Chairman Richard Volz in recognition of his services to the Conference and the R&A Society.

In addition to keeping track of conference finances, Mr. Hayman and his wife Edith have handled many other crucial logistical details of the various conferences, including choosing and negotiating with hotels, printing and mailing, and registration. He has also kept statistical data on the various conferences and as the only professional staff member of the Conference committee has provided a valuable continuity from year to year.

Compliant Motion Control Seminar Sponsored by Princeton R&A Section and Rutgers University

On August 8 the IEEE Robotics and Automation Chapter - Princeton Section, together with the Computer Aids for Industrial Productivity (CAIP) Center at Rutgers University organized a joint seminar entitled "Compliant Motion Control for Robotic Arms and Multifinger Hands". The speaker was Dr. Kazuo Tanie, Director of the Cybernetics Division, Robotics Department at MITI, Japan.

Dr. Tanie spoke extensively on the theory of compliant motion control for both redundant and non-redundant manipulators. He then presented some experimental results obtained at MITI. His talk ended with a video presentation of the five-year national advanced robotics program in Japan. New Jersey researchers could thus see demonstrations of advanced robots in a country that heads the robotics revolution.

--Grigore Burdea,
Rutgers University
Chairman, R&A Chapter
Princeton Section.

The Deadline for items to be included in the Winter issue of the newsletter is *December 1.* Submissions by e-mail are appreciated, but should be accompanied by a hard copy.

From the Editor

Michael B. Leahy, Jr.
Air Force Institute of Technology

Greetings and welcome to another issue of the Society Newsletter. I hope everyone had an enjoyable and productive summer. My name is Mike Leahy and starting with this issue I have assumed editorship of the newsletter. As my first official act as (or I would like to extend my thanks to Wes Snyder for his efforts in creating and sustaining the newsletter. I would especially like to thank Wes for leaving me with three associate editors and the managing editor, his wife Rosalyn. We have an excellent nucleus upon which to grow with the society.

As Wes mentioned last month I am an associate professor of electrical engineering at the Air Force Institute of Technology (AFIT). I am also a captain in the USAF.

One of the most common questions I get when I first meet people is, "what is AFIT?" AFIT is the graduate education arm of the Air Force and is composed of three schools which (h everything from contract management to nuclear physics. The primary emphasis inside the School of Engineering is to provide a masters level education to Air Force officers and DOD employees. We do have a small PH.D. program, but it is our emphasis on the masters level that is the major difference between our school and other graduate institutions. Our research goals are oriented toward providing solutions for the Air Force organizations that fund our research. For the most part my job responsibilities are like that of most university professors. One of those responsibilities is to be of service to professional organizations like this society, which has given me the opportunity to edit this newsletter.

I see my role as a focal point for leading the newsletter in the directions that will best meet the needs of the society. What direction should that growth take? My sense is that the fundamental basis of the newsletter should remain unchanged, a timely source of information about the many activities happening within the society. We have some new initiatives that will start appearing in the subsequent months, but we really need your input.

After you look through this issue please take a minute and send me an e-mail message about what features you liked, and what you would like to see. If you are part of a research team send us a one or two page article, in LaTex or another ASCII format, that describes your laboratory and current research projects. The *Reports from the Labs* section is a great way to advertise your efforts. After my report on research at AFIT I received requests for additional information from around the world. Use the new section on new arrivals to let the community know about your recent Ph.D. graduates. Knowledge of their new job location is especially helpful for people who have been tracking their research.

The newsletter is also an excellent place to let people know about local chapter and technical committee activities. In the last issue we ran reports from the local arrangements and program chairman from the 1990 conference. We will extend the same courtesy to the organizers of any conference that has robotics as part of its theme. We will continue to solicit and publish e-mail addresses of society members. If you have not already done so please send Rosalyn or myself an e-mail message. We will see that your name gets added to our e-mailing list which will allow you to be reminded of important dates like newsletter submission deadlines. Upon request we will also make that mailing list available to individuals.

The society and the newsletter are what you make them - become involved, contribute to the newsletter and reach out and touch 6000 fellow robotics and automation researchers. To reach out and touch me, send e-mail to *mleahy@blackbird.afit.af.mil* or phone 513-255-9269. My blue uniform makes me easy to spot at conferences, stop and say hello and tell me what about robotics excites you. I am looking forward to meeting with many of you in the upcoming year and helping create the type of newsletter that best fits the needs of our growing society.

MBL

DeFiguiredo Named Educator of the Year by Texas Group

Rui J.P. de Figuiredo, a professor of electrical and computer engineering and mathematical sciences at Rice University, was named 1990 Technical Educator of the Year by the Clear Lake Council of Technical Societies.

De Figueiredo heads the Rice program on intelligent systems and robotics. He specializes in research on machine vision problems and will lead researchers in a recently announced robotics and automation consortium that will develop remote operations robotics systems for NASA's planned Space Station Freedom. Rice, Texas A&M University, The University of Texas at Austin and The University of Texas at Arlington will collaborate with NASA in this consortium.

The Clear Lake Council of Technical Societies is an organization that brings together 10 technical societies to promote and support access to technical information and stimulate professional advancement and goodwill. The Council annually honors outstanding leaders chosen from the members of the 10 societies.

E-Mail Directory

Changes/Corrections

Name	Institution	Email	FAX
Wesley E. Snyder	Bowman Gray Sch. Medicine, Wake Forest Univ.	wes@mrips.bgsm.wfu.edu	
Vladimir Lumelsky	Yale University	lumelsky@robios.eng.yale.edu	
Harry Stephanou	Rensselaer Polytechnic Institute	hes@ral.rpi.edu	
New Entry			
Zahari Taha	Universiti Malaya	zahari@umvax.um.my	

New Arrivals

Congratulations on completing your Ph.D.!

Shree Nayar. Carnegie Mellon University, *Thesis*: Computer Vision, *Advisers:* K. Ikeuchi and T. Kanade, *.Destination:* Columbia University.

David Rowland Smith. Georgia Institute of Technology, *Thesis:* Design of Solvable 6R Manipulators, *Adviser:* Wayne Book, *Currently:* Post-doc at Ga. Tech.

Greg Maliotis. Georgia Institute of Technology, *Thesis:* Adaptive Control of Partially Known Robotic Manipulators, *Adviser:* F.L. Lewis, *Currently:* Boeing Aerospace, Kennedy Space Center.

Darren M. Dawson. Georgia Institute of Technology, *Thesis:* Uncertainties in the Control of Robot Manipulators. *Currently:* Asst. Prof., Clemson University.

Ajit Singh, Columbia University. *Thesis:* "Image Flow Computation: an Estimation Theoretic Framework, Unification and Integration" *Adviser*: Peter Allen. *Currently :* Siemens Corporate Research Laboratories, Princeton, NJ.

Chai-Ju Wu, University of Kentucky 6/90, *Thesis:* Time Optimal Planning of Robotic Manipulators, *Advisers:* Fred Trutt, T.S. Chung *Currently:* Fellowship Student, UK, Center for Robotics and Manufacturing Systems

Yiming Rong, University of Kentucky 12/89, *Thesis:*A Study on Joint Dynamics in Joint Dominated Systems: Modeling, Simulation, Identification, Diagnostic Monitoring and Vibration Control. *Adviser:* H.S. Tzou *Currently:* Post-doc, UK Center for Robotics and Manufacturing Systems

Faculty advisers are invited to send us information regarding recent Ph.D. graduates. Please include the name of the University, the thesis title, adviser's name, and the graduate's current position.

IEEE Robotics & Automation Society Newsletter Advertising Policy

Our limited budget prevents us from running gratis full page announcements for conferences, workshops, etc., not sponsored by the IEEE Robotics and Automation Society. However, upcoming events of interest to our readers will be listed on a space available basis in the Calls for Papers and Calendar at no cost. Advertising rates for classified and display advertising are available from the Managing Editor, (919)851-1433.

1990 R&A Conference Draws Record Attendance

A.J. Koivo, Purdue University
1990 Program Chair

The 1990 IEEE International Conference on Robotics and Automation held in Cincinnati, Ohio, May 13-18, had a record attendance of 778 participants, including 65 student helpers/ attendees. We had hoped to attract a large student population to the conference because of the central location of the conference site relative to many Midwestern universities. This goal was indeed realized by the 251 student attendees. A surprising fact of the non-student participants is that almost one third of them are not members of the IEEE.

The international community of automation and robotics was represented by persons from 23 different countries. Each of these countries had at least one active participant in the technical program as a speaker and/or as a session chair. Most of these participants came from Canada (55), Japan (35), France (22), Italy (17), United Kingdom (16), and Republic of China (9). Approximately 43% of the non-students came, not surprisingly from the U.S. It was somewhat unexpected that in this group California had the largest representation (94), followed by Ohio (54), Massachusetts (43), New York (35), and Pennsylvania (35).

The conference was organized so that the technical program of the contributed papers was presented on Tuesday, Wednesday and Thursday. It was preceded by the workshops and tutorials on Sunday and Monday and followed by a tutorial and workshop on Friday. The workshops and tutorials were attended by 234 persons (total) with the ratio being 2:1. These figures reflect the need for continuing education, which is one of the primary targets of the Educational Committee of our Society.

The technical program consisted of 336 papers (selected from 772 papers submitted) They were presented in 84 sessions in three days. The sessions were very well attended. Based on the average attendance figures reported to me by the chairpersons of the sessions, the most attractive topics of the sessions were (in order of their popularity): telerobotics, mobile robots, their navigation, trajectory generation for their motion, and sensor-based feedback control; the compliant motion and learning control of robotic manipulators, redundant manipulators; and software applications.

In view of the theme of the conference, "Intelligent Automation and Robotics," we were hoping to have a reasonable balance in the number of the papers on automation and robotics (which nouns appear in the name of our Society). Although the number of the contributed papers dealing with automation and manufacturing at our conference was considerably larger than in our previous conferences, we were still quite far from a balance. With the help of the authors (the researchers), the technical program in the future hopefully will come closer to balancing the papers on these topics.

The papers presented at the conference describe results of a variety of projects, many of which are supported by various organizations. The conference participants, particularly those from the USA should find the following (*unofficial*) statistics interesting.

The major sources of support acknowledged in the contributed papers of the Conference Proceedings describing projects conducted in the USA are : National Science Foundation is acknowledged by individual researches in 52 papers, by presidential young investigators (PYI) in 14 papers, whereas only 7 papers acknowledge the support of Engineering Research Centers (ERC) of the NSF (two from the ERC on Intelligent Manufacturing Systems at Purdue University, two from the ERC on Systems Research at Harvard/ University of Maryland, two from the ERC on Communication Systems at Columbia University, and one from the Center of Robotic Systems at University of California, Santa Barbara). The support of NASA is recognized in 30 papers; Office of Naval Research (ONR), DARPA and Department of Energy (DOE) in 17 papers each; Army Research Office in 9 papers; and Air Force Office of Scientific Research (AFOSR) in 7 papers.

Among the supporting agencies outside the USA, National Science and Engineering Council of Canada is acknowledged in 11 papers, and NATO in 6 papers.

This list is not exhaustive. It shows only the most often cited organizations. It should also be mentioned that some acknowledgments were not specific enough for a clear classification.

The initial figures on the financial aspects of the 1990 Conference are very positive. The details of the finances of the Conference will be reported at the next meeting of the Administrative Committee (AdCom) of the Society.

Our conference has been continually growing, both in the number of submitted papers which must be reviewed and the number of participants. For example, the technical

(1990 R&A Conf. cont. on page 6)

U.S. Manufacturing: An Agenda for Competitiveness

John A. Alic
Office of Technology Assessment

While the service industries now account for roughly 70 percent of U.S. Employment, manufacturing retains its his historic importance in the economy. Not only does it account for the lion's share of exports and imports, and hence the nation's unprecedented trade deficit, manufacturing remains a major source of high-wage jobs.

To reverse the decline in U.S. manufacturing competitiveness, American firms will have to do better in terms of costs, quality, and flexibility. Costs are central; everything else the same, American products cost too much to design, develop, and build. But everything else has not been the same. American goods have also fallen behind in quality -- first in quality of manufacture (conformance to design specifications), more recently in quality of design (functional attributes and performance). Finally, many U.S. firms lag behind their foreign rivals in introducing more flexible production systems, suited to small-lot production with little or no sacrifice in efficiency.

Improvement will require attention to both the "software" of manufacturing -- organization of work, integration of people and equipment, shop floor management, and to the "hardware" of production equipment and processes themselves. Given its unmatched capabilities in science and in engineering research, the United States has the potential, latent though it may be, to move relatively rapidly toward an industrial base centered on high-technology manufacturing. Among the areas that warrant high R&D priority, the following stand out as promising substantial payoffs:

- the engineering and science base for metalworking processes
- integrated R&D on new materials and processing
- practical feedback control systems for manufacturing
- automated methods for nondestructive evaluation , inspection, and quality control.
- improved techniques for production control and scheduling
- computer methods in support of simultaneous product and process design.

At the same time, pursuit of such a research agenda would accomplish little without greater emphasis on the software and organizational aspects of production. Because of the hardware-centered perspectives of American engineers and managers, few U.S. Companies have taken full advantage of the systemic possibilities for productivity improvement even at current levels of hardware technology.

John Alic was a plenary speaker at the 1990 IEEE Conference on Robotics and Automation. This abstract of his address summarizes the author's personal view, which are not necessarily those of the Office of Technology Assessment.

1990 R&A Conference (Cont.)

program committee had almost 40 members and each one was asked to handle the reviews of 15-25 papers in a very short time, which is a considerable task. It may be proper at this time to consider the possibility that our Society would have annually two conferences; each one could emphasize specific areas. As a member of the Robotics and Automation Society, please convey your ideas on this matter and provide feedback about the conference as well as other issues of the Society to members of the AdCom.

Finally, I would like to express my sincere gratitude not only to the authors of the contributed papers but also to everyone involved in making the 1990 Conference successful. It is the active interaction between the individuals that makes a conference interesting and attractive to the participants. Thank you.

--AJK

COSMIC Software Available from NASA

A brochure describing some of the more recently developed computer programs available from NASA in the area of control systems and robotics is now available from **COSMIC,** NASA's Computer Software and Information Center, located at the University of Georgia. The 11 programs described are:

- **DIVERS** - Digital Flight Control Systems Translator
- **SAMSAN** - Modern Numerical Methods for Classical Sampled System Analysis
- **INCA** -Interactive Controls Analysis
- **FSD** - Flexible Spacecraft Dynamics
- **ORACLS** - Optimal Regulator Algorithms for the Control of Linear Systems
- **APT** - NASA Enhanced version of Automatically Programmed Tool Software
- **CARE III** - Computer Aided Reliability Estimation
- **SURE** - Semi-Markov Unreliability Range Evaluator
- **CO-ST-IN** -Control-Structure-Interaction
- **ALPS** - A Linear Program Solver
- **CFORM** - Linear Control System Design and Analysis: Closed Form Solution and Transient Response of the Linear Differential Equation

The programs range in price from $200 to $4000 and include the source code. Documentation may be purchased separately. Over 1000 computer programs, representing applications in every area of NASA project involvement, are available from COSMIC, which was established in 1966 to provide a central office to collect the software developed under NASA funding and to make it available for reuse by industry, universities, and other government agencies.

To order a copy of the *Control Systems and Robotics Collection* or to obtain more information, contact Pat Mortenson, COSMIC, The University of Georgia, 382 East Broad Street, Athens GA 30602, Phone (404)542-3265.

University of Kentucky Center for Robotics and Manufacturing Systems

Research. Education. The transfer of technology to Kentucky industries.

Those are the three basic functions of the Center for Robotics and Manufacturing Systems at the University of Kentucky, according to the center's director, **Dr. William Gruver.**

During 1989-90. the center has attracted more than $1.5 million for projects sponsored by private industry and governmental agencies.

The center has many ongoing research projects in which it works as a partner with major corporations, including IBM, General Electric, and Philip Morris. Research support also comes from NASA, NSF, NIST, and other government agencies.

On the educational horizon is a new master's degree program in manufacturing engineering which is expected to enroll 40 students within the next five years.

An important part of the Center's mission is the research which is frequently done for small and mid-sized Kentucky companies. The center's industrial extension engineers, who visit Kentucky industries and diagnose their problems, have worked with more than 100 Kentucky manufacturers.

Current research projects include:

- an artificial neural network that learns to recognize patterns
- a computer model of a human limb that would be used to build individualized prostheses from CAT scan images
- a mobile robot that can detect and extinguish fires
- an assembly cell in which several robots assemble products
- a computer vision system automatically inspect manufactured parts for flaws
- a two-legged walking robot
- new epoxy adhesives that replace soldering on electronic circuit boards
- a multi-fingered robot hand
- an expert system to process information from ventilation systems in mines to improve safety.

CORRECTION

The telephone number for the EXOS corporation given in the New Products section of the Summer '90 issue was incorrect. The correct number is 617-229-2075.

Robotics Research for Advanced Reactors

Frank Sweeney
Oak Ridge National Laboratory

The increasing concern of scientists over the existence of global warming or the "greenhouse effect" has led to renewed interest in nuclear power. Nuclear power can be seen as one of many possible alternatives to the burning of fossil fuels (coal, oil, gasoline, and natural gas) and the production of atmospheric carbon dioxide.

Reactor manufacturers have learned from their operating experiences with current light water reactors that the next generation of nuclear facilities must be able to operate more safely and economically. These advanced reactors are designed to be small (for decreased power density and reduced cost), modular (so that additional units can be added as power demands grow), and inherently safe (so that complex engineered safety systems are not needed in the event of an accident). Many of the reactor designs such as the Power Reactor Inherently Safe Module (PRISM) reactor being considered by the General Electric Nuclear Energy company, the Integral Fast Reactor (IFR), and the Modular High Temperature Gas Cooled Reactor (MHTGR) may have the provision for reprocessing the spent nuclear fuel elements at the reactor site to prevent diversion of weapons material and reduce the risk of releasing radioactive wastes into the environment. The increased emphasis on safety in these advanced reactor concepts also applies to the plant workers who must perform routine tasks such as equipment inspection and maintenance.

In order to achieve safe conditions for these plant workers, the U.S. Department of Energy has sponsored research in robotics at Oak Ridge National Laboratory (ORNL) and four universities: the Universities of Florida, Michigan, Tennessee, and Texas. The goal of this program is to develop a generation of advanced robotic systems capable of economically performing tasks that are hazardous to humans, that generate significant occupational radiation exposure, and whose execution times can be reduced if performed by an automated system.

Robots currently in use by utilities at light water installations are generally special purpose devices (so called "on-off" construction), teleoperated, and require significant operator training to be utilized effectively. Many of these robots are simply platforms for the delivery of instrumentation packages to gather information about a hazardous environment. As a result of these practices, the capital and operating costs of these robots are quite high. In some instances, the robot will be used for only one type of operation, such as a repair, and then be discarded.

Research performed by ORNL and the universities is directed at providing a transition from the current practice of pure teleoperation to the capability of autonomous operation using general purpose robots. The development of general purpose robots to perform skilled labor tasks in restricted environments is expected to have extensive economic and safety payback in areas of energy systems (both nuclear and fossil units), chemical plants, fire fighting, space operations, underwater operations, defense and other hazardous activities.

The approach adopted by the team to meet the program objectives has been the staged transition to successive generations of mobile robot prototypes. The first prototype, the Hostile Environment Robotic Machine Intelligence Series - 1 (HERMIES-IIB) was utilized to demonstrate the ability of a mobile robot to autonomously navigate around obstacles in a laboratory environment, recognize a control panel, and read a pair of indicating meters. The HERMIES-IIB robot weighs about 150 pounds and has two onboard computers including a hypercube type parallel computer. About 20,000 lines of C code were required for the robot to execute its mission.

Seeking even more complex autonomous operations, HERMIES-III was constructed at ORNL's Center for Systems Advanced Research (CESAR) lab. HERMIES -III weighs approximately 2,000 pounds (without batteries), carries a seven degr of-freedom redundant manipulator, 32 sonar range sensors, 2CCD video cameras, and a laser range camera. Using this robot, the team demonstrated the autonomous cleanup of a simulated hazardous chemical spill. The demonstration required 50,000 lines of C code executing on 9 different on-board and off-board CPUs.

These prototypes are clearly not designed from an environmental standpoint to be placed in a nuclear facility. The team is currently researching radiation hardening issues

continued on back cover

The Utility/Manufacturers Robot Users Group (U/M RUG)

Harry Roman
Public Service Electric & Gas Co.
Chairman, U/M RUG

With the emergence of robotics technology and its potential application in the utility industry, electric utilities have begun to experiment with and evaluate the performance of off-the-shelf and prototypical robotic devices. Much of this interest stemmed directly from the use of robots during the cleanup of the Three Mile Island nuclear plant.

The primary purpose of these teleoperated devices is to remove utility operation and maintenance personnel from potentially hazardous working conditions. Other benefits derived from the use of robots are increased productivity and minimization of equipment down time.

Hazardous utility environments could include radiation, toxic material atmospheres, corrosive atmospheres, high temperature /humidity conditions, high pressure hydraulics, high voltages, potentially explosive hazardous conditions, and general safety hazards.

These specific hazardous conditions could be encountered in nuclear, fossil fueled, and hydro-electric power generating plants, electric transmission distribution facilities, and substations and switching stations. There are also important potential robotic applications in the natural gas, potable water, and sewage utility systems.

The need to employ devices which will enhance the safety aspects and limit the hazard potential to the utility worker has been widely recognized. However, there have been no national, coordinated efforts directed toward the development, promotion, and employment of robotic devices which could promote risk reductions for the utility worker while enhancing efficiency in working in the hazardous environment.

In an effort to accelerate the application and development of cost-effective utility robotic systems and to install a viable mechanism for the effective transfer of appropriate technology, a group of electric utility organizations promoted the formation of the Utility /Manufacturers Robot Users Group (U/M RUG).

The U/M RUG meetings, which are held three times each year, provide a forum where users' and manufacturers' technology can be brought together to identify new application areas, propose development of new equipment, and assess the cost benefit potentials of robotic technologies. It is the only group of its kind and represents a unique methodology for the utility industry to interact with robotic manufacturers and other interested parties to influence the application of utility specific robotic devices.

Meeting attendees are exposed to some of the most recent and unique robot applications and are able to have hands-on experience with robot demonstrations. Membership in U/M RUG is free and attendance at the meetings is free and open to any individuals interested in robotics. Recently the membership of U/M RUG has expanded dramatically to include professionals from NASA, the US Nuclear Regulatory Commission, various national laboratories, and experts in the use of robotics in the construction and human services industry.

The results of these efforts to increase awareness and use of robots are evident in reports of significant cost savings to U/M RUG members associated with the use of robots. Some have realized payback of robotic equipment in as little as a few months. Savings can easily range from $10,000 to $50,000 per robot per year. One utility reports saving $2 in operating costs for every $1 spent on robot hardware. U/M RUG is in the process of compiling a data base on utility applications and the savings associated with these applications.

Achievements which have come from U/M RUG meetings include

- Input to the clean-up of TMI 2
- Provided the U.S. State Department with robotic application ideas for the inspection and clean-up of Chernobyl
- Briefed the US NRC on the potential for robotics in US nuclear plants
- Hosted international visitors from Canada, France, Holland, Japan and the USSR
- Worked with the Electric Power Research Institute (EPRI) to develop an educational handbook on robotics for utility companies
- Participated in EPRI's robotic exposition in Charleston, SC in March 11989, which was held in conjunction with an annual ANS meeting.

For more information please contact the author at Public Service Electric and Gas Company, Tel: 201-430-6646

Rehabilitation Robotics Research Program Alfred I. duPont Institute & the University of Delaware

Michel L. Gilbert

The purpose of rehabilitative robotics is to provide a person who has manipulative disabilities with an interactive aid to carry out personal and vocational tasks, thus increasing his/her level of independence. ***Ongoing research projects at the A.I. duPont Institute in areas of robot control, safety, and human/ machine interaction include the following:***

Task Oriented Control

Task Oriented Control is being investigated as a superior approach to interactively controlling a manipulator in a rehabilitation setting. Emphasis is placed on improving both the organization of the model and the manipulator implementation based on clinical use and user feedback.

Hybrid Force/Position Control

Using the task-oriented control scheme, a user could wipe the surface of a sphere by selecting the radius of the sphere, then controlling the two degrees of freedom of the sweep mode: azimuth and elevation. However. this will only work for a perfect sphere that is located precisely. Slight position errors during the wiping action can cause the implement to rise above or be forced into the sphere, possibly damaging the surface. To overcome this problem, we consider how a non-disabled person would perform this task. The person would probably apply a slight force directed towards the center of the sphere during the wiping motion. In this way, even if the surface is not a true sphere, the manipulator will remain in contact throughout the motion. The proposed Target-Centered Hybrid Force/Position Control scheme could therefore allow the user to perform such contact operations in a safe and easy manner.

Analog Control Project

The Data Glove, a man-machine interface device produced by VPL Research, consists of two distinct sensing systems. The first of these consists of a glove with its photo sensors and the second consists of a position sensing device made by Polhemus Navigation Sciences. The device is called a 3-Space Isotrak.To date this project has been concerned with the creation of a programming library, written in C, to allow easy access to the Data Glove and present its output in a meaningful manner. Future plans for the Data Glove include the acquisition of a second position sensing unit so that data concerned with the orientation of the entire upper limb may be used. In addition the present system will be applied to the control of the RTX robot by UMI (Universal Machine Intelligence). A small study will soon be undertaken to record the arm motions of twenty children with cerebral palsy and twenty non-disabled subjects using the 3-Space sensor. The investigators hope to establish a new means of quantifying the severity of athetoid movement.

Programming Environment

The Programming Environment Project addresses the need for a standardized rehabilitation robotics programming environment. Designed for the professional robotics programmer, this environment would include all of the basic software and hardware tools necessary for minimizing the engineering effort involved in developing a specific clinical or research application.

The primary component of the Rehabilitation Robotics Programming Environment is the robot control library. A prototype control library has been implemented on the RTX. The robot library is composed of a layered structure of robot-specific implementation functions on which is imposed th top-level architecture of a standard interface. The bottom-most level of functions controls the basic communication between the PC and the robot. The next level implements low-level control control over the robot's actuators and control parameters, which are required to begin and control motion of the manipulator. These two levels comprise the *robot implementation level.* Although these functions will be accessible to the user, their use requires complete knowledge of the control and communication protocol of the robot.

Other Projects

Activities have begun toward the establishment of several new projects including:

- Development of a small compliant robot for children
- Studies in the use of head motion for robot control
- Development of assessment procedures for evaluation of a rehabilitation robotic system
- Development of an educational workstation in collaboration with Ohio State University.

A longer version of this report appeared in the Rehabilitation Robotics Newsletter, PO Box 269 Wilmington DE 19899, Judy Trefsger, editor.

Calendar

November 5. Workshop on Intelligent Robotic Systems: Design and Applications. Boston, Massachusetts.. Held in conj. w/ SPIE's OE/BOSTON '90 and organized in coop. w/ the IEEE Computer and Systems, Man & Cybernetics Societies. *Contact::* Mohan M. Trivedi: tel: (615) 974-5450, FAX (615)974-5459, e-mail: trivedi@vms1engr.utk.edu; mail: Univ. of Tennessee, Electrical & Computer Eng. Dept., Univ. of Tennessee, Ferris Hall, Knoxville TN 37996-2100.

November 26-29 IEEE Conference on Neural Information Processing Systems - Natural & Synthetic Denver, Colorado. NIPS-90 Post-Conference Workshops will be Nov. 30-Dec.1 at a ski resort near Denver. *Contact:* Kathie Hibbard NIPS*90 Local Committee, Engineering Center, Univ. of Colorado, Campus Box 425, Boulder CO 80309-0425.

January 3-5 1991. International Symposium on Intelligent Robotics. Bangalore INDIA. *Sponsor*: Center for Artificial Intelligence of India in coop. w/ IEEE Robotics & Automation and Systems Man & Cybernetics Societies and IFAC.

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. SEE CALLS FOR PAPERS.

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 61330616

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

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

June 18-20, 1991. International Ocean Technology Conference. Glasgow, Strathclyde, UK. *See Calls for Papers*

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. *SEE CALLS FOR PAPERS..*

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. *See Calls for papers.*

Calls for Papers

4th IEEE Conference on Micro Electro Mechanical Systems (MEMS).

Jan. 30-Feb. 2., 1991. Nara JAPAN
Sponsor: IEEE Robotics & Automation Society *in cooperation with* IEE of Japan and the ASME Dynamic Systems & Control Divisions.
The Workshop embraces the design, fabrications, operation and application of devices, machines and systems constructed of millimeter-scale or smaller electromechanical elements.
Recent MEMS developments can be submitted as two-page abstracts for consideration as Late-News papers by **November 15, 1990.**
Send all correspondence to:
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 3 359 932

IEEE Workshop on Directions in Automated "CAD-Based" Vision,

June 2-3, 1991 Maui, Hawaii (just prior to CVPR '91)
The program will consist of a small number of submitted papers, "proponent/respondent" discussions on selected topics, panel sessions, and presentations by some potential "consumers" of machine vision on what they feel are important real problems in need of a solution.
Possible themes for submitted papers include but are not limited to

- Derivation of Vision-Oriented Object Models from CAD Models
- Model-Driven Extraction of Relevant Features from Images
- Strategies for Matching Image Features to Object Models

Cont. on back cover

- Capabilities of Current CAD-to-Vision Systems
- "Qualitative Vision" and Automated Learning

Submission of Papers: Submit three copies of your paper to the program chairman to be received on or before **January 1, 1991.** Papers should not exceed a total of 25 double-spaced pages. Authors will be notified of reviewing decisions by **March 1**, and final versions will be due by **April 1.**
General Chairman: Linda Shapiro (shapiro@cs.washington.edu), Dept. of Computer Science and Engineering, University of Washington, Seattle, Washington 98195
Program Chairman: Kevin Bowyer (kwb@sol.usf.edu), Dept. of Computer Science & Engineering, University of South Florida, Tampa, Florida 33620.
Program Committee: Avi Kak, Purdue University; Joe Mundy, General Electric Corp. R.&D.; Yoshiaki Shirai, Osaka Univ.; George Stockman, Michigan State Univ.; Jean Ponce, Univ. of Illinois; Katsushi Ikeuchi, Carnegie-Mellon Univ.; Tom Henderson, Univ. of Utah; Horst Bunke, Universitat Berne; Prasanna Mulgaonkar, SRI International.

International Ocean Technology Conference

June 18-20, 1991, Glasgow, Strathclyde, U.K. Session themes include: Renewable Energy, Living Resources, Non-living Resources, Waste Management, Environmental Assessment, and *Space Utilisation/Transportation.* This session, chaired by Norman Caplan of the U.S. National Science Foundation, is of particular interest to researchers in Robotics and Automation. Extended abstracts of 2-4 pages should be sent by **October 12, 1990** to
Claire Bowie
IOTC Organising Committee
9 Royal Crescent
Glasgow G3 7SP
Strathclyde, UK
Tel: 041-332-0193
Fax; 041-332-02

International Conference on Advanced Robotics: Robot Systems in Unstructured Environments

June 20-22 1991, Pisa ITALY. *Sponsors:* CNR(Nat'l Research Council of Italy, Consorzio Pisa Ricerche, Scuola Superiore sS. Anna, Pisa, University of Genoa, University of Pisa, In cooperation with IEEE Robotics & Automa' Society, INRIA, (France) , Japan Industrial Robot Association, Italian Association for Robotics.
ICAR was established in 1983 to be the primary event for illustrating national and international projects on advanced robotics.
Submissions: 4 copies of full papers (8-10 double-spaced pages) in English should be sent to :
Prof. Paolo Dario
'91 ICAR Secretariat
Consorzio Pisa Ricerche
Via Risorgimento 9
I-56126, Pisa Italy by
October 31, 1990.

12th International Joint Conference on Artificial Intelligence

August 24-30, 1991, Sydney, Australia.
Sponsor: IJCIA, Inc.; Cosponsor: National Committee on Artificial Intelligence and Expert Systems of the Australian Computer Society.
Topics of interest include but are not limited to:
Architectures and languages for AI
Automated reasoning
Cognitive modeling
Connectionist and PDP models
Knowledge representation
Learning and knowledge acquisition
Logic programming
Natural language

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Calls for Papers cont. fr. p. 11

Philosophical foundations
Principles of AI applications
Qualitative reasoning and naive physics
Robotics
Social, economic and legal implications
Vision.

Papers must be sent by **December 10 1990.** Contact one of the program committee cochairs for further 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: ijcai@cs.toronto.edu

Videotape submissions must be sent by **December 10, 1990.**

For information about submitting videotapes or arranging tutorials, workshops and panels, contact the appropriate chair:
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Fax (+1 415)326-5512 (Note: include Att: Martha Pollack, AI Center) e-mail: pollack@ai.sri.com

Robotics for Advanced Reactors (cont. from page 8)

associated with CPU chips and circuit boards and hopes eventually to build and field a fully hardened robot prototype. The experiments and research performed by the team have led us to the conclusion that while human operators are not likely to be completely replaced, machine autonomy can significantly reduce the burden of training and operations on humans. We have found that very complex tasks can often be completely automated. The team believes that the technology for at least partial autonomous robot operation exists today and could be implemented on commercially available devices.

It is hoped that, through this program and the commitment to human safety by the operators of nuclear facilities, robots will someday completely replace humans in advanced reactors, and other hazardous environments.