Newsletter of the IEEE Robotics & Automation Society

ROBOTICS AND AUTOMATION

Volume 5 Number 2 March 1991

In This Issue

THE INSTITUTE OF ELECTRICAL
AND ELECTRONICS ENGINEERS, INC.
IEEE

1991 IEEE INTERNATIONAL CONFERENCE ON

Registration Form

ROBOTICS AND AUTOMATION

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

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

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

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

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

Name ______________________

Company ______________________

Address ______________________

City/State/Zip/Country ______________________

Telephone No. ______________________
(Where you can be reached during the day)
IEEE Membership Number ______________________

Please Register me as follows (Circle appropriate fee).

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

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

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

Payment Enclosed $__________

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

Card No. ______________________

Exp. Date ______________________

Signature ______________________

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

B

1991 IEEE INTERNATIONAL CONFERENCE ON

ROBOTICS AND AUTOMATION

HOTEL REGISTRATION FORM

Name ______________________

Company ______________________

Address ______________________

City/State/Zip ______________________

Country ______________________

Daytime Phone Number ______________________

Arrival Date and Time ______________________

Departure Date and Time ______________________

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

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

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

Cardholder's Name ______________________

Card Type ______________________

Card No. ______________________

Exp. Date ______________________

Signature ______________________

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

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

FROM THE EDITOR

Dr. Michael Leahy
Air Force Institute of Technology

I hope everyone in northern climates has had at least one chance to spend a few days in a warm spot this winter. I spent a week down in San Antonio, Texas and the weather was a welcome relief from dreary Dayton. During my visit I got a chance to see the robotics research facilities of several local universities and research centers.

Dr. Tesar has a well equipped laboratory in the Mechanical Engineering Department of the ***University of Texas at Austin.*** His research team, consisting of over 30 students, is pursuing a wide range of topics and I found their projects on modular robots and precision actuators to be particularly interesting.

Under the direction of Dr. Raju the ***University of Texas at San Antonio*** is pursuing a dramatic expansion of facilities and faculty. Once the dust settles I expect to see contributions in the areas of sensor technology, multi-robot control, and precision positioning of end effectors from that group.

The ***South West Research Institute*** is a nonprofit corporation with a strong division involved in a broad range of applications related systems research in robotics and automation. Their demonstrated ability to turn theory into reality is impressive.

That concentration of robotics expertise is one of the reasons that the Air Force Logistics Command has begun the creation of a ***Robotics and Automation Center of Excellence*** at the San Antonio Air Logistics Center. The center will serve as a focal point for robotics and automation applications and research. Air Logistics Centers are huge operations that can literally rebuild an aircraft system from scratch. The potential benefits from insertion of intelligent machine technology are enormous, but so are the challenges of the remanufacturing environment. If anyone is looking for a real challenge with direct applications, remanufacturing will provide all you can handle.

The minimal amount of research currently performed in precision machining has a direct relationship with the increasing vocal concerns from industry that academia is not meeting their needs. That issue will be the subject of a special panel discussion at this year's Robotics and Automation Conference in Sacramento California during April. Panel members will be distinguished members of both communities and I look forward to a lively discussion. Also included in this issue is advance announcement information about the entire conference week. A full advance program will be mailed separately to all society members.

To aid in developing better relations between industry and academia, the newsletter will start running regular features on events and developments in the commercial sector. Assisting us in that process will be the ***Robotic Industries Association (RIA)***. The RIA is sponsoring the special session at the conference and is briefly described in an article in this issue.

We have all heard many stories about Japan and robotics. In this issue two members share their impressions of working in a Japanese robotics research center and of forming a distribution relationship between a small US firm and a larger Japanese company. Both articles are enlightening and I thank the authors for volunteering their time. Does anyone else have a story they want to tell?

Also in this issue is an article on the transputer-based experimental control system at Boston University. This article is representative of the type of submission we are seeking for our special Fall issue on ***Experimental Environments.*** Write up a short description of your set up. Block diagrams and pictures, especially those in ***Postscript*** format, are welcome. If you think fellow researchers should emulate your systems, tell us why. The goal is to get a condensed picture of the options available to researchers interested in revising existing facilities or creating new ones.

Finally, don't forget to check out our regular columns. We have a laboratory report from the University of Pennsylvania, several new arrivals and people on the move, and a large calender of events to peruse. Keep your articles and suggestions coming. I hope to talk with many of you during the upcoming conference. Look for the tall guy dressed in blue.

--mbl

The President's Letter will appear in the next issue. President Norm Caplan offers his apologies and looks forward to seeing you in Sacramento.

The next newsletter deadline is May 1!! Send your items NOW!

The 1991 IEEE International Conference on Robotics and Automation

Prof. T. C. Hsai,
University of California, Davis
General Chair

The Organizing Committee looks forward to welcoming you to the 1991 IEEE International Conference on Robotics and Automation to be held in the Hyatt Regency Sacramento, April 7-12, 1991. We invite you to participate in the activities of this major annual meeting of the IEEE Robotics and Automation Society. A wide range of topics is covered in the contributed and invited papers to be presented in 108 sessions on Tuesday (April 9) through Thursday (April 11).

Because of the large number of contributed technical papers, the Technical Program Committee has been able to assemble a program of high quality papers. Your active participation in the sessions of interest to you will contribute to the success of the Conference.

The conference, as usual, offers several tutorials and workshops on Sunday (April 7), Monday (April 8), and Friday (April 12).

Each conference registrant should pick up at the Registration Desk a package containing the conference material and local information.

•Plenary Sessions

Two plenary sessions will be included in the program. On Tuesday morning, Dr. Alain Bensossan of INRIA, France, will speak on "Some Trends in Control and Automation" and on Thursday morning, Professor Hirofumi Miura of the University of Tokyo, Japan, will present his views on "What is the Intelligence of Robots?"

•Video Proceedings

For the first time, the Robotics and Automation Conference offers a **Video Proceedings.** The video tape, in VHS format, consists of 33 experimental presentations in recent robotics and automation research. These video segments were selected by members of the Video Proceedings Committee from a large number of contributions. The video will be presented at the conference in a video theater and will be available for purchase in both NTSC and PAL standards.

•Receptions and Banquet

The welcoming and get-acquainted reception will be held on Tuesday, April 9, 1991 from 19:00 - 21:00 at the Regency Ballroom. The reception is hosted by ***Intel Corporation.***

•Banquet

The conference banquet will be held on Wednesday evening, April 10, at 20:00 at the Regency Ballroom. It will feature the presentation of Dr. Craig R. Barrett, Executive Vice President of Intel Corporation on "Automation and the Computer Revolution: What will happen to automation with the move from mainframes and minis to the local client/server form of computing?"

Banquet tickets are included in the registration package of non-student participants. Additional banquet tickets will be available at the Registration Desk until 17:30 on Wednesday. Special meals should be requested before that time. Persons who are not planning to attend the banquet are asked to turn in their tickets at the Registration Desk for the benefit of starving student attendees.

• Authors' Breakfasts

For the speakers and chairs of the Technical Sessions, a breakfast will be served the morning of their duties at 7:00 a.m. Each chair will meet with the authors of his/her session at a single table. This will give your session chair the opportunity to explain how he/she will chair the session Please provide him/her with your biographical sketch. If you are giving a talk on your paper at the Conference, please plan to attend the breakfast on the day of your session.

•Conference Special Meeting Room.

A special room has been arranged for committee and other small group meetings during the conference. A coordinator will be located in the registration area during the conference to assist with scheduling.

•Technical Tours

Technical tours to local industries and university laboratories are being arranged. They include visits to Hewlett-Packard, NEC, Intel, the U.S. post office in Sacramento, and Stanford University. Sign up for technical tours at the Conference Hospitality Desk.

•Exhibits

Exhibitions will be sponsored by book publishers, commercial and noncommercial organizations, developers of hardware and software products, and various industries and agencies dealing with control and

1991 R&A Conference Video Proceedings

The 1991 Robotics and Automation Conference has produced a Video Proceedings which will be available for purchase at the Robotics and Automation Conference and later from the IEEE. The Video Proceedings will be available both in NTSC and PAL standard formats. The conference price will be $55.00.

While other conferences are also producing video proceedings, the unique character of the field of robotics and automation is especially suited to this medium. ***Some of this stuff simply must be seen!***

The Video Proceedings presents new and significant experimental work and demonstrations in robotics and automation. have been produced to enhance and complement the theoretical results presented in technical papers of the conference proceedings.

From the 66 entries which were submitted for review by the Video Proceedings Committee, 32 segments were selected. These were revised and carefully edited by the IEEE Educational Activities Department into the final format shown in this videotape.

In addition to the United States, contributions came from as Canada, Europe, Japan, and China. The video segments are grouped into the following eight categories:

- Manipulator Design
- Sensing
- Manipulator Control
- Vehicles
- Automation
- Robotic Hands
- Telerobotics
- Walking

robotics system design and advanced automation.

•Travel Arrangements

•Air Transportation

Delta Airlines, in cooperation with the IEEE International Conference on Robotics and Automation, is offering special rates which afford a 5% bonus off Delta's published roundtrip fares within the United States and San Juan, providing all rules and conditions of airfare are met. If special fares do not coincide with your travel dates a 40% discount off Delta's unrestricted round-trip coach rates will be offered. (Travel from Delta's Canadian cities will apply at a 35% savings.) Seven days advance reservations and ticketing will be required.

•Ground Transportation

For transportation between the Sacramento Metro Airport and the Hyatt Regency, you can take one of the following shuttle services: Downtown Shuttle (916-448-8886), Sacramento Airport Transit (916-424-9640), Skyline Airporter (916-444-2222), Star Shuttle (916-665-1391) and the Hyatt Hotel Shuttle (916-443-1234). The fares range from $7 to $9 per person one way. Taxi fare is around $22-$28 for a 15 minute ride.

•Climate and Attire

Sacramento enjoys a mild climate year-round, with an abundance of sunshine. Climate in April is pleasant, with a temperature in the mid 60's. Springtime attire should be comfortable.

•Local Attractions

Sacramento is a historically rich area offering plentiful opportunities to explore and enjoy the heritage of California's capital city. Major attractions in the city include the State Capitol, California State Railroad Museum Crocker Art Museum, Old Sacramento Waterfront, and Towe Ford Museum of California.

•Excursions

There are many interesting excursions available within two hours driving distance, such as the Napa Valley wine country, the city of San Francisco, Lake Tahoe and casinos, and Marineworld Africa USA in Vallejo.

Carleton Travel Network/Capital Prestige Travel, Sacramento is providing post-convention vacation packages for conference attendees departing from Sacramento. These are:

- ***•Disneyland Vacation*** -- three days/two nights including round trip air transportation, hotel and par admission, starting at $272 per person (based on double occupancy).
- ***•Hawaii*** -- three to seven day packages, including round trip air and hotel, starting at $499 per person (double occupancy)
- ***•Yosemite Valley***--two days/one night including round trip travel via Amtrack, hotel, lunch and sightseeing, starting at $160 per person (double occupancy).

Carlson Travel Network agents can also book your round trip air travel on Delta using the Robotics and Automation Conference special convention airfare. For detailed information and booking, call Carlson Travel Network at (800)274-2509 or (916)447-1534.

Found amid the email messages on a dreary February day: *I will be in Rio de Janiero attending a conference on geometric modeling and studying the algebraic geometry of string bikinis. Back March 1.*

Tutorials and Workshops

1991 IEEE International Conference on Robotics and Automation

Workshop S1: (Sunday, April 7, 1991 - 1:00PM- 6:00PM)
Intelligent Sensory Perception for Space Based Robotics
Organizer: James, R. Carnes, Vanderbilt University

Workshop S2: (Sunday, April 7, 1991, 2:00PM - 5:00 PM)
Intelligent Robotic Systems: Theory Design and Applications
Organizer: Kimon P. Valavanis, Northeastern University

Tutorial M1: (Monday, April 8 - 9:00 AM - 5:00 PM)
Petri Nets for Automated Manufacturing Systems: Modeling Control and Performance Evaluation
Organizer: Alan A. Desrochers, Rensselaer Polytechnic Institute

Tutorial M2: (Monday, April 8 - 9:00 AM - 5:00 PM)
Neural Networks for Intelligent Robotics Systems
Organizer: Behnam Bavarian, University of California Irvine

Tutorial M3: (Monday, April 8 - 9:00 AM - 12 Noon)
Piezoelectric "Smart" Systems - Applied to Robotics, Micro Systems, Identification, and Control
Organizers: H.S. Tzou, University of Kentucky, and Toshio Fukuda, Nagoya University

Tutorial M4: (Monday, April 8 - 2:00 PM - 5:00 PM)
Modular Architecture for Robot Structures
Organizer: Delbert Tesar, University of Texas, Austin

Workshop F1: (Friday, April 12 - 9:00 AM - 5:00 PM)
Manufacturing System Control Software Workshop
Organizers: D. Neal Scogin, Texas A&M University, Richard Volz, Texas A&M University and Giuseppe Menga, Politecnico di Torino

Workshop F2 (Friday, April 12 - 9:00 AM - 5:00 PM)
Nonholonomic Motion Planning Theory, Algorithms and Applications
Organizer: J. Canny, University of California, Berkeley

Workshop F3 (Friday, April 12 - 9:00 AM - 12 Noon)
The Application of Robotics to the Handling of Hazardous Wastes, Materials and Equipment
Organizer: Richard Paul, University of Pennsylvania

Workshop F4 (Friday, April 12 - 2:00 PM - 5:00 PM)
Computational Methods for Robot Dynamic Path Optimization
Organizer: Richard W. Longman, Columbia University

More information about the Workshops and Tutorials is in the Advance Announcement, the Advance Conference Program, the Winter 1991 Newsletter, and the individual organizers. The fee schedule is on the registration form.

Micro/Cellular Robots TC to Meet in Sacramento

An organizational meeting for the ***IEEE R&A Society Technical Committee for Micro Robots and Cellular Robots*** will be held at the R&A Conference in Sacramento April 7-12. A time and place will be posted near the registration desk. A meeting is also planned at the 5th ICAR in Italy in June 1991.

The activities of the Technical Committee will comprise, without being limited to, the organization of Tutorials and Special Sessions at Conferences co-sponsored by the Society and the organization of dedicated Workshops in the fields of micro robots and cellular robots. Activities of interest relate to the methods and technologies necessary in order to ultimately obtain autonomous or semiautonomous machines capable of carrying out, individually or collectively, useful tasks in the micro or millimeter-scale world.

For more information, contact:

Prof. Paolo Dario,
Chairman ARTS Lab,
Scuola Superiore S. Anna,
Via Carducci, 40, 56100
Pisa ITALY.
tel: 39-50-559269/-207
FAX: 39-50-559225/240
email dario@sssup1.sssup.it

News from Industry

Robotics Industries of America

The following information was provided by the ***Robotics Industries of America,*** (RIA) Founded in 1974, ***RIA*** is one of the oldest robotics organizations in the world.

According to RIA Vice President Donald A. Vincent, RIA is also the only trade organization in North America devoted exclusively to robotics. Its membership consists primarily of robot manufacturers,

It's a Bird! It's a Plane! It's an Aerial Robot!!

On June 29, the skies over Atlanta, Georgia will be the scene of the First International Aerial Robotics Competition. The competition is sponsored by the Association for Unmanned Vehicle Systems and will be held in conjunction with AUVS-91. Among other criteria,the entr ies must be unmanned and autonomous and must compete based on their ability to sense the structured environment of the competition arena. Nine U.S. teams and one from Edinburgh, Scotland will enter this year's competition.

For more information, contact Robert C. Michelson, Chairman, AUVS Technical Committee, Georgia Tech Research Institute, Aerospace Science & Technology Laboratory, Atlanta GA 30332 USA.

distributors, systems integrators, consultants, suppliers and corporate users. RIA plans to seek new relationships in 1991 and work with as many groups as possible to help expand the market for robotics, machine vision, and related automation technologies.

RIA activities include developing ANSI industry standards such as a "Circular Mechanical Flange Interface;" conducting industry-oriented conferences and workshops such as a Robot Safety Conference held in October 1990, conducting surveys and compiling statistics for its members' use, and working with other organizations and associations on mutually beneficial programs.

International Robots & Vision Show and Conference

RIA is also the primary sponsor of this giant annual event, which is expected to draw 13,000 attendees October 22-24 in Detroit.

Associated with the show this year will be the **International Symposium on Industrial Robots,** sponsored by the International Federation of Robots, headquartered in Stockholm, Sweden.

Systems Integrator Directory

The RIA (Robotics Industries of America) and AIA (Automated Imaging Association) have published the Robotics and Vision Systems Integrator Directory. The 200 page book includes information and addresses about 300 companies and will be updated annually.

The 1990-91 edition costs $28 and can be ordered from RIA by calling 313-994-6088 (attn: Elaine).

Engelberger Award Winners

Four international robotics leaders have been selected to receive the 1990 Joseph F. Engelberger Robotics Awards presented by Robotics Industries Association.

They are: **Christof W. Burckhardt,** Professor and Director of Ecole Polytechnique Federale de Lausanne (Switzerland), (Education), **John O'Hara**, Vice Chairman, Asea Brown Boveri, Inc. (USA), (Industry Leadership) **Dr. Bruce Shimano**, Vice President of Research and Development at Adept Technology (USA), (Technology Development), and **Walter K. Weisel**, Chairman & CEO, International Business Link, (Applications).

For more information about RIA, contact Jeff Bernstein, RIA, PO Box 3724, Ann Arbor MI 48106, Tel: 313/994-6088, FAX 313/994-3338.

The Latest Automation in Japan is Licensed from America:

international marketing for a small technology company

Christopher Perrien

Assurance Technologies Inc. comprises 10 former employees of Lord Industrial Automation. ATI develops and markets Force and Torque Sensing Sensors and Signature Analysis Systems for process verification.

The decline of the domestic robot market, beginning in the Fall of 1986, induced Lord Corporation to sell its Industrial Automation Division in September of 1989 and thus created ATI. ATI's immediate strategic marketing and product development goals were to maintain the relationship with our Japanese partners, and to accelerate development of a Force Sensing System that would be accepted in the international marketplace. This plan called for a product of lower cost and increased reliability.

Despite the loss of confidence by its own parent corporation, ATI's incorporation was financed by the parent corporation of our Japanese distribution partner in the form of a below market rate loan, advanced development fees and royalties, and a stream of regular orders with prompt payments. Such an investment demonstrates the Japanese willingness to cultivate new technologies by taking a longer term point of view. By contrast, no commercial funding of any sort was available to ATI from domestic financial sources.

Even though we enjoyed a profitable 3 year distribution relationship, negotiations for the financing package required 7 days and nights of meetings, social events, and often disparate discussions. We were invited to Japan to conclude the deal and upon arrival realized that nothing was to be taken for granted. We would receive our funding by negotiating for it in \$500.00 increments. ATI would be supported and would have to justify such support. Although this treatment caught us by surprise, over time we have become stronger as a result since we learned immediately that positive performance and not relationship would be the measure of our success.

In exchange for this financial support, a technology transfer agreement was signed for ATI's Tool-Changers and Force Torque Sensing Systems.

In 1990, thirty five percent of ATI's Force and Torque Sensing Systems were sold into high tolerance applications in the Japanese factories such as NEC, Maxda, Toyota, and Mitsubishi. Over the next 2 years, this market will become the domain of our Japanese partner as our technology transfer agreement concludes.

ATI is proud of its penetration into the Japanese market and grateful for the valuable lessons taught throughout this association. Because of the differences in culture, manufacturing philosophy, language, and longitude, the relationship with our partners in Japan requires continuous nurturing. In order to sustain the relationship, ATI agreed to maintain one of its applications engineers for one year on the staff of our distribution partner.

Although there is mutual personal regard, I am confident that we would be out of contact as soon as we lost usefulness and that is the intent of the license agreement. ATI's challenge is to design and deliver new products.

However, we must be careful about the design. In their culture, patents are formal decrees inviting imitation. Many inventions never leave the company and are certainly not available for public review. We see many Japanese robots in American factories; there are many more types of robots in Japanese factories that are never revealed to the public.

This technology transfer has been difficult for ATI. We understood that over time our sales to the Pacific would diminish as our partners became self-sufficient in the manufacture of our products. The problem of this diminishing level of sales is complicating by the continued level of product and marketing support from our partner while ATI tries to build new markets to replace this diminishing business.

Throughout our relationship with the Japanese, we have witnessed the methods and value of implementing a technology only after it is fully understood and tested. We have observed what it is really meant by customer service-- our partners think nothing of a 4 hour round trip train ride to present-- not give or mail--the customer with product literature. It is true that a product failure is an embarrassment and not a problem for customer service.

In a typical week, ATI receives orders from England, Spain, Korea, and inquiries from Australia and Germany in addition to the usual correspondence from Japan.

We learned over the past 18 months that success in the international marketplace requires a differ-

A Visiting Researcher's Japan Experience

Kevin Cleary

Last year Kevin Cleary was a visiting researcher in the Robotics Department of the Mechanical Engineering Laboratory (MEL) in Tsukuba, Japan. Tsukuba is a city of about 140,000 people 50 kilometers northeast of Tokyo. The city's full name is Tsukuba Science City, and it is home to 44 national research institutions, 3 universities, and almost 100 private research and educational institutions.

His nine-month postdoctoral visit was sponsored by Japan's Science and Technology Agency (STA) and the U.S. National Science Foundation (NSF). In this article, he shares some of his impressions about Japanese robotics research and Japanese society in general.

Dr. Cleary is currently employed by ST Systems Corporation (STX) of Lanham, MD. He works on-site at NASA Goddard in the Goddard robotics lab.

ROBOTICS RESEARCH

My research in Japan concerned parallel manipulators. When I arrived in March 1990, a prototype parallel manipulator had recently been built at MEL. My job was to write the control software for the manipulator and investigate the manipulator's basic characteristics. Initially, I had some difficulties as the manual for the motor controller boards was written in Japanese and I had no language training before going to Japan. However, my host scientist helped me by translating some of the manual and I could soon write a C program to control the motors. Fortunately, computer languages are universal languages so once I understood what to do, writing the program was not difficult.

There is a great deal of robotics research at MEL. The Robotics Department has about 25 researchers and is divided into four divisions: Mechanisms, Cybernetics, Autonomous Machinery, and Biorobotics. I worked in the Autonomous Machinery division. In my division, the projects included parallel manipulators, walking machines, teleoperation, and computer graphics simulation. In other divisions, projects included telexistence, three-fingered hands, and autonomous vehicles.

While I was in Japan, I visited approximately 20 robotics research institutions and went to three robotics conferences. The laboratories I visited were all very receptive and eager to discuss their work.

From these visits, I saw that there is enormous interest in robotics in Japan. I estimate that there is at least as much robotics research activity in Japan as in the U.S. While it is difficult to categorize all the research activity, I feel that Japanese robotics research usually emphasizes applications more than basic research. At every robotics research laboratory I visited, I saw demonstrations of working hardware.

OFFICE ENVIRONMENT

The Japanese office environment is very different from the U.S. office environment. Few researchers have private offices. At MEL, a typical office might house six to eight researchers and one or two secretaries. The desks are usually very close to each other and everyone shares the phones. While there is almost no privacy, this arrangement has many

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(ATI continued from page 7)

ent set of skills than is required by sales in the domestic marketplace. The latest technology combined with enthusiastic salesmanship is an incomplete formula for success. America's ability to harbor and encourage small technology-based companies can produce in the same companies an inability to function properly in the international marketplace. International customers make a large investment in their work-forces and want to ensure that the purchased products will be supported and improved-- and that these products meet rigorous documentation and testing requirements. Noble goals as well as expensive and time consuming ones for a small, self-funded company.

There are two common areas of manufacturing development in both Europe and Japan: the stature of manufacturing industries attracts high caliber individuals; the Universities plan an integrated role in development of new products. In Europe, the Universities are used as product testing facilities. Such partnership keeps these schools from wandering off the path of applied development and provided the corporations with properly and independently tested equipment.

Christopher Perrien is General Manager of ATI, 503D Hwy 70, Garner NC 27529

advantages. For example, time is not wasted searching for colleagues, and new researchers can learn by observing their seniors.

The Japanese social life revolves around the office. There is great interest in sports at MEL, and many people use their lunch hour to play tennis, soccer, softball, or golf. While the Japanese often work longer hours than their American colleagues, they also know how to enjoy themselves. Perhaps once a week there will be an office party to welcome a new arrival, celebrate a holiday, or just to have a party. The conference table is cleared of papers, and lots of food and drink are brought out. A variety of foods including noodles, fish, and vegetables are cooked. Beer, sake, and whiskey are also enjoyed. Often the party ends just in time for workers to catch the last bus home.

Communicating with my Japanese colleagues was not a problem. Almost all Japanese scientists speak English, and my wife and I attended Japanese language classes sponsored by STA. While spoken Japanese was not too difficult, written Japanese was extremely difficult since there are three types of Japanese writing: ***kanji, hiragana, and katakana.*** Kanji are ideographs that try to convey ideas pictorially, while hiragana and katakana are phonetic syllabaries. By the end of my stay, I could handle simple tasks like asking if I was on the right bus in Japanese, but I could not have a detailed discussion in Japanese. In addition, due to the difficulty of the written language, I could not read the Japanese technical literature.

While many factors contribute to Japan's economic success, I think that one of the most important is the lifetime employment system. While lifetime employment is not all encompassing in Japan, there are almost no instances of the job hopping individual so common in the U.S. At large private companies and government labs, lifetime employment is the general rule. While lifetime employment would probably not work in the U.S. for all sectors of the economy, the system has several advantages. First, workers tend to think of the long term. Second, businesses invest heavily in training, confident that they will reap the benefits of the training. Third, almost all Japanese who so desire have an opportunity to study abroad at company expense and absorb the latest in American or European technology.

SOCIETY

Certainly, the Japanese lifestyle is different from the American lifestyle, but that doesn't make Japanese customs wrong or strange -- they are just different. With this in mind, a key characteristic for enjoying oneself in Japan is to be flexible and open-minded. Rather than trying to understand why things in Japan are the way they are, one should just relax and enjoy the adventure.

The Japanese have a different view of the role of the individual in society. Japan is a very group-oriented society, as opposed to the U.S., which might be considered a very individual-oriented society. In Japan, individuals are often judged by what contribution they can make to the group. In addition, the Japanese often have group outings for activities such as sightseeing or skiing. For example, our division at MEL enjoyed a two-day sightseeing trip to the resort area of Mount Bandai.

While women comprise approximately 40% of the Japanese work force, many women workers are employed as "office ladies" whose primary responsibilities are to serve tea, answer the phone, make copies, and do other errands. After women are married, and particularly after they have children, there are strong societal pressures for them to stay home and run the household. However, the role of women in Japan is slowly changing, and I did see several young female researchers during my company visits.

RECREATION

My wife and I found that Tsukuba is good for bicycling as it is very flat and has many bicycle trails. From Tsukuba, we took day trips to Tokyo by train or bus for shopping and entertainment. We also visited many other Japanese cities including the ancient capital of Kyoto.

Tsukuba is perhaps the most Western of Japanese cities due to its recent development and the many foreign researchers living there. One interesting aspect of our stay was meeting other foreign researchers who came from all over the world including Asia, South America, and Europe.

Now that I've returned to familiar surroundings in the U.S., I find it hard to believe that I spent nine months in Japan. But I feel I've made a first step towards understanding Japan and its people. I strongly encourage anyone interested in Japan or Japanese robotics to visit Japan and see this fascinating country for themselves.

SUGGESTED READING

"The Japanese Today: Change and Continuity" by Edwin Reischauer (Charles E. Tuttle Company) is a good introduction to Japan. For a visiting researcher, "Gaijin's Guide: Practical Help for Everyday Life in Japan" by Janet Ashby (The Japan Times, Ltd.) may be helpful.

ACKNOWLEDGEMENTS ***I would like to thank the following individuals and institutions for their assistance and support: my host scientist, Dr. Tatsuo Arai; the Mechanical Engineering Laboratory; the AIST International Center; Japan's Science and Technology Agency; the U.S. National Science Foundation; and the many companies and universities I visited.***

Real-Time Control Server

D. P. Martin, S. Weibel and J. Baillieul and D. Seto
Department of Aerospace & Mechanical Engineering,

The Boston University Robotics Laboratory is currently developing an INMOS T800 Transputer-based Real-time Server to act as a host for applications and experiments in robotics and the theory of complex mechanical systems. A graphical user interface is provided by a Silicon Graphics IRIS 4D/120 GTX workstation. The main purpose of this article is to briefly describe the ways in which we addressed the hardware and software issues involved in the creation the Server. We briefly mention some of the applications for which the server was created, but for the most part, these will be treated elsewhere.

1.0 Introduction to the B.U. Real-Time Control Server Network

The Boston University Robotics Laboratory Server Network for Real-Time Control is a custom designed research facility providing a high resolution graphical interface to a parallel network of microprocessors which can be programmed to control a wide variety of mechanical systems. All low level functions involving data acquisition, closing of servo loops, and so forth are implemented using INMOS T800 Transputers - 32 bit microprocessors which support parallel interconnection. Because Transputers support both internal and external interrupts, they provide a real-time environment which is ideal for implementing MIMO control system designs for mechanical systems having many degrees of freedom. A Silicon Graphics 4D/120 GTX IRIS workstation provides the user interface to our Transputer network. Because of its high level support for graphical animation, the IRIS is also used for simulations and graphical rendering of actual real-time data streams from laboratory experiments. In the following sections, we describe the design details of both the hardware and software components of the system. We also describe some dc-motor control applications.

2.0 Overview of the Server Network

The Server Network consists of four components, a Silicon Graphics IRIS workstation, an INMOS B014-1 card containing two TRAMS, a custom designed communications module designed and built by Evergreen Design, Inc., and a lab rack containing four XP/DCS Transputer cards, also built by Evergreen Design. The organization of the network is shown in Figure 1.

2.1 The IRIS Host and Bus-level Interface to the Server Network

As mentioned above, the host for the Server Network is a Silicon Graphics 4D/120 GTX IRIS workstation. This device includes two MIPS Inc. CPU's which have a combined performance of 20 M.I.P.S. Moreover, special purpose graphics hardware (the pipelined Geometry Engine™ processors) provides the IRIS with excellent 3-D graphics rendering capability. (Frequently cited benchmarks include 400,000 3-D vectors/sec and 100,000 3-D polygons/sec.) The workstation performs three functions. First, it is used for simulation and graphical rendering of mechanical system dynamics. Second, since it has a bus-level connection to the rest of the Server Network, it allows real-time graphical rendering of data streams from working experiments. Third, the workstation also serves as host for software development for all nodes in the Control Server Network. The interface between the IRIS and the Transputers in the Server Network is by means of an INMOS BO14-1 board installed in the VME cage of the IRIS. This board is configured with two IMS B404-4 Transputer modules (TRAMs), each of which is a complete microcomputer consisting of a T800 Transputer running at 17 Mhz together with 128Kbytes of SRAM and 2Mbytes of DRAM. The BO14-1 board is compatible with VME bus Specification Rev. C.1 and operates as a VM bus slave. Each of the T800 Transputers has four 20Mbits/sec serial ports called ***Transputer links*** or simply ***links***. These links are designed to provide run-time communication between sequential processes running on different Transputers. Each link consists of a serial output and a serial input, both of which carry data and link control information. The links on the BO14-1 can be configured using two C004 crossbar link switches, and by means of these switches and the COM/MOD communications module described below, link connections can also be established with other Transputers in the network.

2.2 The Transputer network

In principle, all Transputers in the Server Network may be interconnected by INMOS's twisted pair link cables. To insure that 20Mbits/sec link speeds are maintained, however, these cables are restricted to approximately three feet in length. Since for many laboratory applications, the distances between communicating processors should exceed this restriction, a communications module (COM/MOD in Figure 1) has been developed by Evergreen Design, Inc. to provide signal conditioning allowing link communication over cable lengths of up to 10 meters. To be used in real-time control implementations, the Transputers must be interfaced with various other pieces of hardware (A/D, D/A, etc.). In the B.U. Server Network, such interfaces are accomplished using XP/DCS board sets from Evergreen Design. Each set includes an XP/DCS ™ CPU motherboard with a 20 MHz T800 Transputer and an XP/DCS ™ I/O daughter board. Originally developed for use at Yale University, these board sets can be used as computational nodes in a wide variety of laboratory applications. In addition to the T800 Transputer, the XP/DCS CPU board features 128Kbyte (zero wait state) SRAM and a fiber optic interface capability (for operation in EMI hostile environments such as encountered in home-made robot designs). Both the CPU motherboard and I/O daughterboard are standardized to the Eurocard form factor, using a board size of 100mm x 220mm. The backplane connector is compatible with INMOS' ITEM Rack standard, although we are currently using a custom designed lab rack/power supply module. The I/O daughter board derives its power from the XP/DCS motherboard. I/O communication is supported with a latched 32 bit bidirectional I/O bus together with six individually addressable sets of four latched handshaking output lines and eight handshaking input lines. The I/O bus configuration can accommodate interfaces to a wide variety of actuators, sensors, and other devices.

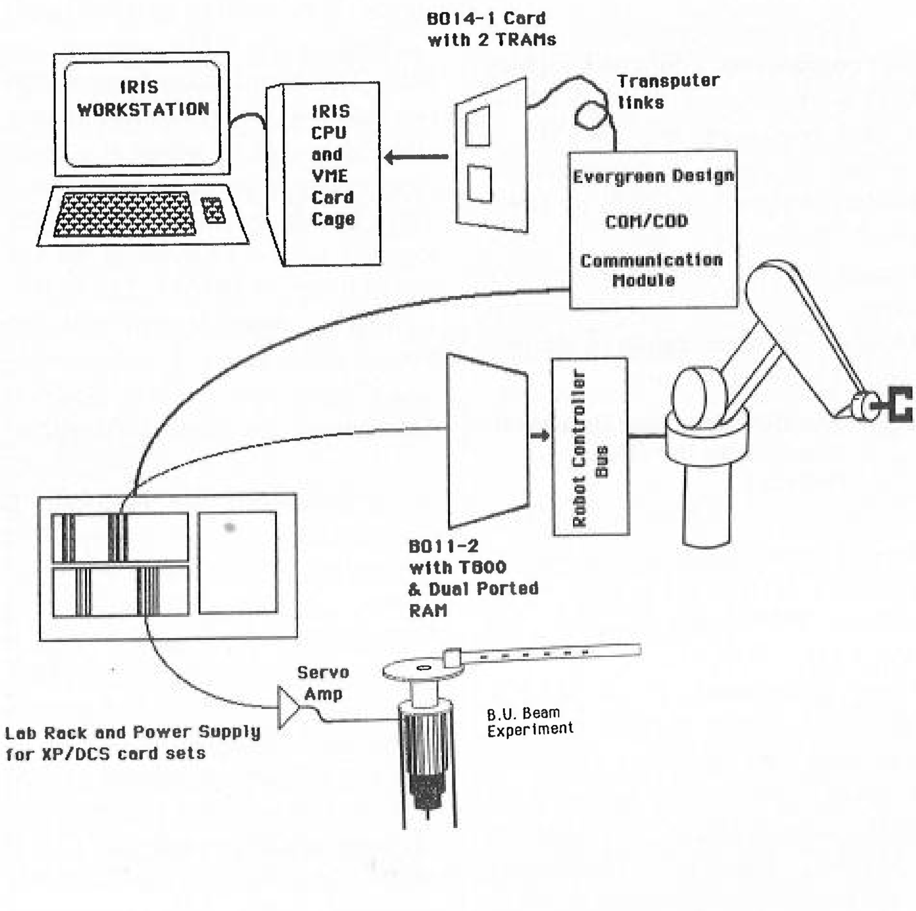

Figure 1: The Boston University Robotics Laboratory Real-Time Control Server

Figure 1: The Boston University Robotics Laboratory Real-Time Control Server

2.3 Language Support and Software Development Tools

The natural language for real-time graphics programming on the IRIS is C. Although C would also be the natural choice in many computer environments for real-time control implementations, the language currently used for the B.U. Server Network is Occam™. Occam bears a special relationship with the Transputer since they have been developed essentially in parallel since 1982 by INMOS. The fact that Occam is the best documented and best supported language for the Transputer must be weighed against the time-cost many programmers face in learning to use features not present in more common languages such as C.

To support high bandwidth, bus-level communication and to allow the IRIS to be used for Transputer software development, a UNIX device driver for the BO14-1 board has been written. A functionally equivalent device driver is available for SUN 3 systems from INMOS as part of the Occam 2 Toolset ™ (IMS D505A). For Sun users, the Occam 2 Toolset provides a fairly complete software development system, and although the modules in the package cannot be run on the IRIS itself, our device driver allows access to most of the development tools (the Occam compiler, debugger, etc.) since these can be run on the designated root Transputer of the BO14-1 board. Moreover, because software may be loaded into Transputer memory via the links, the entire Server Network may be programmed via the Transputers on the VME bus in the IRIS.

3.0 DC Motor Control Using the Server Network

A first attempt at using the Real-Time Control Server Network was to write a graphically based d.c. motor control application. This application, called *MCPANEL* (for Motor Control PANEL), employs a control panel like interface and a graphical cubic spline interpolation program to create position trajectories for PID motor control. Creating this application involved writing the C language graphics interface on the IRIS, and the Occam code for PID motor control. In addition to writing the software to run on the different hardware, special attention was required in defining the message passing conventions between the IRIS host and the Transputer network.

3.1 The SGI IRIS Interface for MCPANEL

The IRIS based user interface consists of two separate programs - a control panel-like program containing graphical dials, buttons, and numeric items, and a program to perform trajectory generation. A Unix shell script initializes the entire application, setting the PID gains, booting the Occam motor control software on the Transputer network, and opening a graphics window in which the control panel runs. The control panel and the Transputer software are able to establish communications over the VME bus after all of the different programs are running, using a predefined message protocol.

The graphical rendering of the control panel, ***mcpanel*** (to be distinguished from the entire application *MCPANEL*), as shown in Figure 2, contains five 'panels'. The two 'dials', identified by the words ***Position*** and ***Velocity,*** serve as analog meters and display the position and velocity (in rad/s) respectively. The panel in the upper right contains three buttons - one to execute the trajectory generation program, one to execute the trajectory on the d.c. motor, and a button to exit the program. At the middle-left and at the bottom of the window there are two more panels displaying numeric data.

At program initialization, this program begins reading data from link 0 of the network's root Transputer. The communications link is made accessible to standard Unix I/O calls via a device driver that supports the VME-bus link adapter interface on the B014 board. Any data streaming in is read into a byte array in a C ***union*** data structure, which is used to rectify byte and word order differences between the Transputer and the IRIS. From this array, position, velocity, set point, and cycle information is obtained. The control panel reads this information and updates the graphical display as fast as possible, while handling any interrupts from the mouse and performing any other operating system related functions. Whenever a mouse event (pressing a mouse button) occurs, the control panel program checks the position of the mouse cursor. If the cursor happens to be over one of the graphical buttons, the program performs the desired function, otherwise it ignores the event.

If the event is to generate a trajectory (Gen. Path), the ***mcpanel*** executes the trajectory generation program ***traj*** as an independent Unix process. This program is illustrated in Figure 3. Trajectories are defined from the cubic spline interpolation of user defined data points. Data points are entered by means of mouse events. The user can save trajectory files, delete points, clear the grid, exit the application program, by selecting the buttons at the bottom of the window shown in Figure 3.

If the control panel program detects an event to run a trajectory (Run Path), the program attempts to load a predefined trajectory file and communicate the trajectory over the

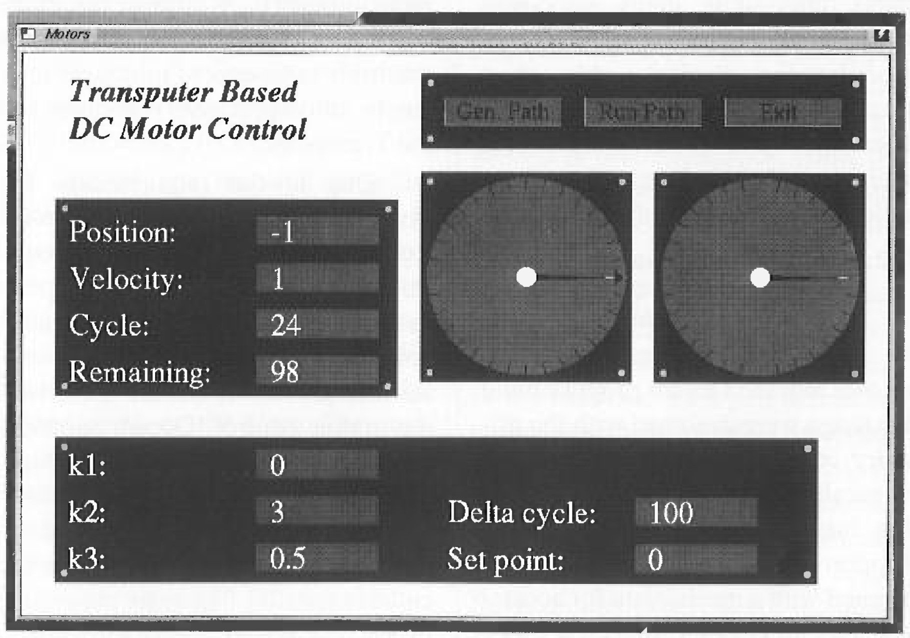

Figure 2: Motor Control Panel

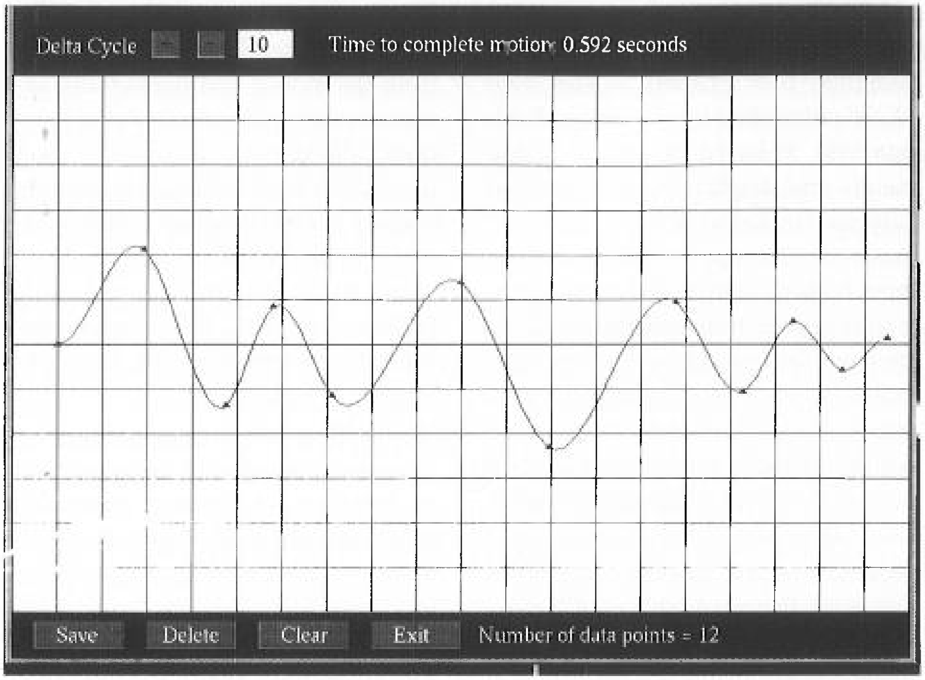

Figure 3: Interactive Trajectory Generation

VME bus to a process running on the Transputer performing the motor control. If the file does not exist, the control panel quits trying to load the file and continues.

Menus, buttons and other panel items were implemented directly in C, using the IRIX 3.2 system services. A current project is to standardize such items (buttons, scroll bars), plus some items associated with common laboratory instruments (oscilloscope displays, strip chart recorders, dials, etc.) and create a library of C functions to allow for inclusion of such items as program objects in future control applications.

3.2 Transputer Based PID Control and Occam Real-Time Programming

The Transputer machine architecture and the Occam programming language were designed with the primary goal of supporting distributed or parallel processing. It happens that the language features intended to support distributed processing, augmented with a mechanism for accessing the processor's timer or clock provide all of the functionality normally provided by a real-time programming run-time environment. On the Transputer, one has the advantage that the real-time support is provided very efficiently at the machine instruction level.

Single axis d.c. motor control is essentially a single processor operation, and as such does not exploit the resources of a multiprocessor Transputer network. It does, however, make use of the ***multi-tasking*** (multiple independent processes on a single microprocessor) features of the Transputer.

Due to the requirements for asynchronous communication with the IRIS, it is necessary that the control operation consist of two independent processes, one process to handle communications with the IRIS and another process to handle the actual d.c. motor control. Occam supports single processor parallelism through the ***PAR*** construct. PAR essentially acts as the beginning of a block of processes, all of which will be executed in parallel. The main procedure of the Transputer based PID motor control program essentially consists of three lines - PAR followed by the process to handle the asynchronous communications with the IRIS, followed by the process which performs the motor control.

Occam processes communicate by means of ***channels***. A channel is a unidirectional, ***blocking*** message protocol. The term unidirectional implies that there is only one independent process sending and one process receiving data on a channel at a time. The mechanism is referred to as blocking because the reader of a channel will wait, or block, until the writer sends a message; similarly, the writer blocks until the recipient process reads the message. The Ada rendezvous is a generalization of the Occam channel communication mechanism.

Occam supports real time control applications by providing variables of type ***timer***. These variables are unique in that they act as independent timer processes, but one obtains a timer's value by reading it like a channel. Timers are initialized at zero when started, and an Occam program can contain as many timers as the available memory will support. In the d.c. motor control application described here, a timer channel is used to determine the time interval at which motor control actions will be taken.

The process responsible for control, the "periodic" process of Figure 4, is also responsible for handling the input commands arriving from the IRIS over the communications link. It is able to handle asynchronous input from both the timer and the command channel by means of the Occam ***ALT*** construct. Within an ALT clause, reads on multiple channels may be posted, and the first channel written upon will be processed. While this processing occurs, 'write' operations on the other channels will block, until the process is complete and executes a 'read' of the other channel---in this case by executing the ALT clause again. The process executing the ALT clause blocks until a write on one or more of the channels occurs. This allows other processes to execute in the interim. Thus, the periodic input from the clock (a timer channel) and asynchronous command input from the IRIS are handled by a single process. When the clock timer input is ready, control processing is performed, when a command arrives from the IRIS it is either saved to be executed on the next clock cycle, or executed immediately, as appropriate.

On each cycle of the periodic control process, output data is written to a buffer process. The buffer process, itself consisting of two sub-processes, is needed to prevent the control process from blocking when the output data channel is not being read. The IRIS reads the buffer, again asynchronously, to obtain the most recently available output data..

The periodic control process communicates with the communications process and deals with the motor I/O hardware directly. It reads an array of motor trajectory set points over its input channel from the IRIS as described above, and attempts to control the motor to these positions using feedback from the motor tachometer and an optical shaft encoder attached to the motor shaft. Special purpose boards built by Evergreen Design perform the position and velocity decoding.

In the current implementation of the controller, the control process is allowed 100 clock ticks (one clock tick equals 64µs) between control actions. For the simple PID controller implemented, it has been found that the control process requires two clock ticks, or 128 µs, to perform the control computations. That the control process waits for 98 clock ticks between actions indicates that much more demanding control applications are feasible.

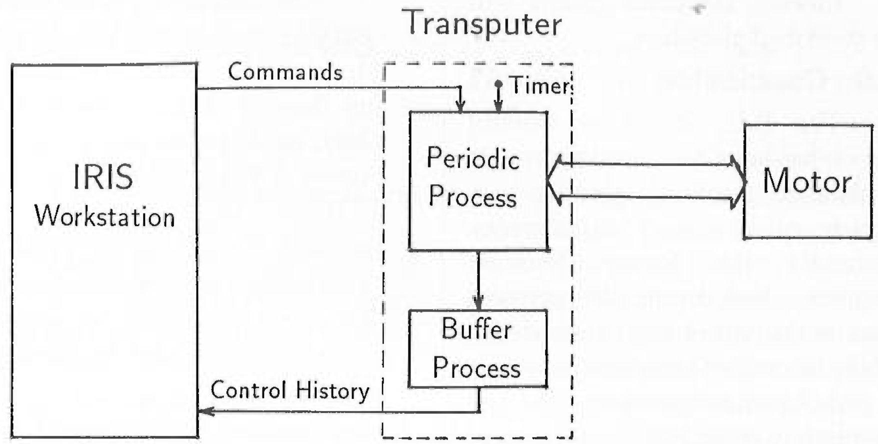

Figure 4. Motor Control Interprocess Communication

4.0 Simple Mechanical Experiments Involving the Server Network

Because Transputers are relatively inexpensive, it is possible to implement a multiprocessor system having many nodes. Thus, in principle, the B.U. Real-time Server can be expanded to host systems having large numbers of controlled degrees of freedom. For the moment, however, the systems we are controlling have only single actuators, and we are experimenting with multiprocessor architectures in which sensing, control, and the user's real-time graphical interface are distinct intercommunicating processes.

One of our research projects involves a rotating flexible beam experiment. This experiment consists of a d.c. motor mounted in an upright position with a flexible stainless steel beam mounted on the shaft. Strain gages are mounted at carefully chosen points on the beam. The goal of the experiment is to use strain feedback to control beam deformations and the relative position of the free end of the beam under rotation. Important features of the experimental apparatus include its incorporation of slip rings and its provision for attaching the base of the beam to the central hub at points other than the center of rotation. The slip rings permit the study of both large angle slewing maneuvers and beam dynamics under continuous unidirectional rotations. The various possibilities for attaching the base of the beam to the hub allow experimentation in controlling the beam when nonlinear effects dominate the dynamics. (See, for instance, [1] or [2] for a discussion of nonlinear beam dynamics.) In the past, this experiment was run using an Intel 8086-based PC. Because of the complexity of the computations (especially in the nonlinear regime), pc-based control of the beam proved infeasible for all but the simplest models of beam dynamics. Using the Server Network, the tasks of obtaining strain feedback, updating the beam model, performing control calculations, and sending voltage outputs for the actual motor control are distributed among three Transputers in the network. This parallelization, coupled with the 17MHz operating speed of each T800 and the 64 µs resolution of each Transputer internal clock, allows the high bandwidth needed for controlling the beam. Several other experiments, including a 2 d.o.f. "gymnast" and various rotating kinematic chains will be described elsewhere.

1.0 Conclusion

The B.U. Real-time Control Server has been developed to provide a standard graphical interface to a variety of laboratory experiments. Currently the Server Network requires a high degree of sophistication on the part of users (knowledge of the laboratory apparatus as well as C and Occam programming). We are currently writing both C and Occam code with the aim of standardizing the principal features of control programs which run on the network. Our aim is to develop libraries in C and Occam to provide programmers an with environment in which to develop control applications with sophisticated graphical interfaces and standard I/O and motor control functions.

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2. Baillieul, J., and Levi, M., (1991), "Constrained Relative Motions in Rotational Mechanics," to appear in ***Arch.for Rational Mechanics and Analysis***

Acknowledgment: Support for hardware for the B.U. Real-time Control Server has come from the Air Force Office of Scientific Research and the INMOS Corporation.

We would also like to thank Woody Levin (Evergreen Design) and Martin Buehler for superb board designs. Dan Koditschek, one of the guiding lights of Transputer based control, played a role by infecting us with his enthusiasm

RPI CIRSSE Conference

A. Desrochers
Rensselaer Polytechnic Institute

Rensselaer's Center for Intelligent Robotic Systems for Space Exploration (CIRSSE) held its Annual Conference in Troy, NY on November 29 and 30, 1990. CIRSSE was established in 1988 as a NASA University Space Engineering Research Center.

Conference speakers included representatives from industry, NASA, Rensselaer, and other universities. Extensive laboratory demonstrations were also done by the CIRSSE faculty and graduate students.

On Thursday, ***Dr. Tibor Vamos***, member of the Hungarian Academy of Science, was the Keynote Speaker and spoke on Epistemic Background of Problems of Uncertainty. This was followed by an overview of CIRSSE's activities during the past year and was presented by Drs. Saridis and Desrochers.

The first technical session, chaired by Professor Lester Gerhardt, presented Rensselaer's work in 3-D Sensing and Space Based Applications, and Restoration of Distorted Depth Maps Calculated from Stereo Sequences.

On the second day Charles Price from the NASA Johnson Space Center gave a keynote address on Space Station Freedom Robots and Their Role in External Maintenance. Emphasis was on the future of robotic systems in space. Next, a session on Dual Arm Control was chaired by Professor Steve Derby. It focused on CIRSSE's work in Dual Arm Path Planning and Dual Arm Modeling.

Technology Transfer issues were discussed by K.Z. (Brad) Bradford of Martin Marietta. The talk was based on his experiences with commercial applications of Flight Telerobotic Servicer Technologies

Robotics Research at the GRASP Laboratory

Xiaoping Yun and H. Anderson

The *General Robotics and Active Sensory Perception (GRASP)* Laboratory of the University of Pennsylvania does research in various areas of robotics including coordinated control of multiple robot manipulators, strategies for robotic sensing, multi-sensor integration, distributed real-time operating systems, telerobotics with communication delays, image understanding, and range image analysis. Major equipment includes three PUMA250's, two PUMA560's, two custom sensorized robotic hands, two grippers, a foveal/peripheral pair of robot-mounted Sony CCD cameras, a robot-mounted structured light laser rangefinder, and other range measurement devices and cameras. Computational equipment includes Sun4's, SparcStations, Sun3 workstations, MicroVaxes, HP workstations, a Personal Iris, IBM workstations, a DataCube, a pyramid processor, and a Connection Machine CM2a with a dedicated Sun4/280 front end.

The GRASP Laboratory has approximately thirty graduate students, seven faculty members, five staff members and five undergraduate employees.The students and faculty are from four departments (Computer and Information Science, Systems Science and Engineering, Mechanical Engineering and Applied Mechanics, and Electrical Engineering). The multidisciplinary approach of the GRASP Laboratory reflects the mission of the University of Pennsylvania's School of Engineering and Applied Science, where students participate in the creation of knowledge at the leading edge of their particular fields of interest, and integrate knowledge to create new devices and systems. Funding for the GRASP Laboratory comes from governmental and industrial sources

•Coordinated Control of Multiple Manipulators

Dynamic coordination of multiple manipulators is investigated to enhance the capability of manipulators for grasping and manipulating large, heavy, and irregularly shaped objects. Using differential geometric control theory, a coordinated control algorithm, which explicitly controls both the interaction force and motion trajectory, has been developed. The algorithm utilizes a dynamic nonlinear feedback to exactly linearize and decouple the nonlinear system of multiple manipulators. The control of contact conditions (rolling and sliding) in multi-arm manipulation and multi-handed grasping is also being studied. To demonstrate the approach, the Two Robotic Arm Coordination System (TRACS) has been developed, using two PUMA 250 robots and an IBMPC/AT based controller. Using two instrumented open-palm end effectors developed in the lab, the TRACS is capable of grasping and dynamically transporting large objects such as cardboard boxes, not graspable by individual manipulators.

•Design of Robot Manipulators

We have been investigating techniques for improving robot manipulator performance. We have developed a method of passive and energy conserving mechanical gravity compensation, which can be applied to a wide range of manipulator geometries. Also, we are working on modifying the transmission characteristics for a robot manipulator to improve the predictability of actuator response. We have developed and built several new manipulators, such as a four degree of freedom mechanical hand with 14 tactile sensors, a two link arm with gravity compensation, and a three-degree of freedom pneumatic wrist or ankle joint

•Active Sensory Perception

The ultimate goal of robotics in the GRASP Laboratory is to build robotic systems that function in completely unstructured environments. Active perception makes use of robot-mounted CCD cameras, range imaging systems, and tactile sensors.

Mobile cameras seek to position themselves in the best viewing location for maximum information extraction. Robotic devices with attached sensors manipulate an object to learn about the object itself. This technique, employing passive sensors in an active fashion, purposefully changes the sensor's state parameters according to sensing strategies. The active sensing paradigm includes taking multiple measurements and integrating them, and including feedback not only on sensory data but on complex processed sensory data. Irrespective of the actual control algorithms used, a complete model of the system is absolutely essential. Such a model of a robot system must account for the dynamics of the robot manipulator, the end effector, the sensor devices, the environment or external object, and the controller itself. An example of this work is the construction of a complete spatial map of a 3-D scene using a robot-mounted structured light (laser) rangefinder. A single range image is taken, then a strategy is developed to select the appropriate next view. A PUMA 560 moves the scanner, a new range image is taken, and the new data is integrated with data from the first view. The process continues until a complete spatial map is obtained.

Another area of research is the investigation of geometric and mechanical properties of objects, such as identifying movable and removable parts of an object. Also, we are working in the areas of color image segmentation, combined 2-D and 3-D shape analysis, and texture analysis.

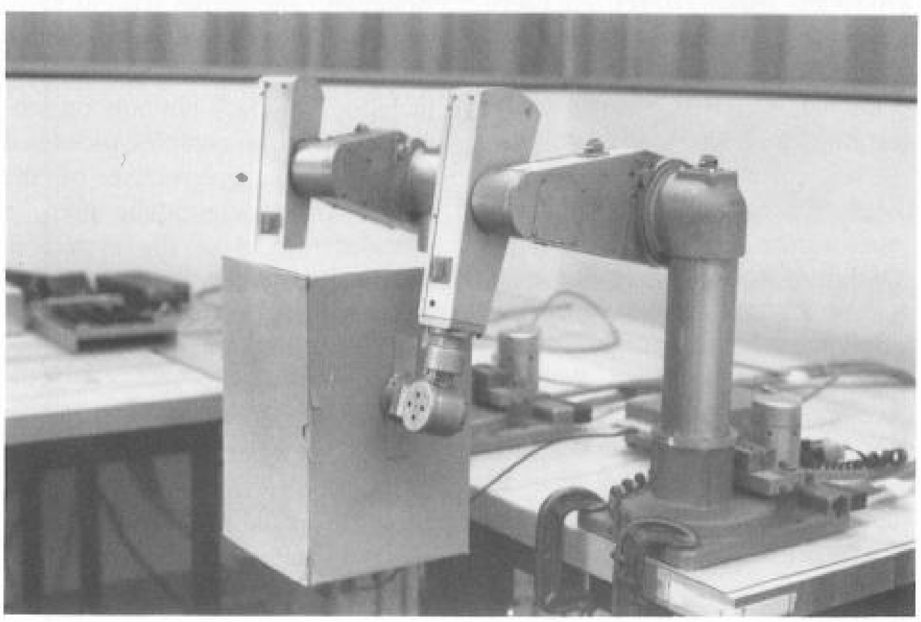
•Multisensor Integration Theory and Application

The combination of sensor data can be modeled as a statistical problem and then analyzed using statistical decision theory. Robust sensor fusion can be used in an environment with sensor noise and inexact statistical descriptions.

The GRASP Laboratory has developed techniques which allow us to accommodate uncertainty in real sensor noise distributions, to gain significant improvements in estimation of location (range) data. In addition to work on range data, which is one dimensional, work is being extended to the multi-dimensional case. For each uncertainty class of real noise distributions, we need to obtain a minimax rule based on a zero-one loss function. These rules minimize the maximum probability that the absolute error of estimation is greater than an error tolerance. At the GRASP Laboratory, these developing theories of multisensor integration are applied to real sensor data

•Teleoperation with Feedback Delay

Delay occurs with earth-based teleoperation in space and with surface-based teleoperation with untethered submersibles when acoustic communication links are involved. The delay in obtaining position and force feedback from remote slave arms makes teleoperation extremely difficult. We use a combination of graphics and manipulator programming to solve the problem by interfacing a teleoperator master arm to a graphics based simulator of the remote environment coupled with a robot manipulator at the remote, delayed site. The operator's actions are monitored to provide both kinesthetic and visual feedback and to generate symbolic motion commands to the remote slave. The slave robot then executes these symbolic commands delayed in time. While much of a task proceeds error free, when an error does occur the slave system transmits data back to the master and the master environment is be "reset" to the error state.



•Real-time Distributed Systems

Our multi-sensor multi-robot systems execute in real-time on a number of different processors linked by a local area network. We have been investigating the programming, operating systems and formal specification issues of distributed real-time systems. For real-time systems to be correct, they must not only be functionally correct but also satisfy timing constraints. Our approach is to treat "time" explicitly within programs so that their temporal behavior can be specified and reasoned about. We have been developing programming concepts of temporal scope for expressing timing constraints, timed communication for predictable delay, and timed atomic commitment for coordinating subsystems. We have developed a real-time kernel called Timix, which uses integrated scheduling of processes and messages based on timing constraints, and are implementing it for a distributed two-robot system. Also, we are developing a formal resource-based computation model of time dependent processes and a process algebra, called Communicating Shared Resources.

For further information about research activities at the GRASP Laboratory, contact Dr. Xiaoping Yun (215-898-6783, yun@central.-cis.upenn.edu). Laboratory reports and publications are available upon request.

Calendar

- **April 7-12. IEEE International Conference on Robotics & Automation.** Sacramento CA. Sponsor: IEEE Robotics & Automation Society. SEE ANNOUNCEMENT.
- **April 12-14 1991 Cambridge Workshop on Rehabilitation Robotics,** Cambridge England. Contact: Robin D. Jackson, Dept. of Engineering, Cambridge University. (44)223 332690, FAX: 44 332 3332662 email: jackson@uk.ac.-cam.eng
- **May 20-24. ISATA, International Symposium on Automotive Technology and Automation** Florence, Italy. Sponsors: 40 companies and research groups. Information: ISATA Secretariat, 42 Lloyd Park Ave., Croydon, Surrey CRO 5SB, England. Tel: 081-686 1329 Fax: 081-686 1490.
- **June 2-3**. IEEE Workshop on Directions in Automated "CAD-Based" Vision. Maui, Hawaii (just prior to CVPR '91) ***Contact:*** Steve Graham, Department of Electrical Engineering FT-10, University of Washington Seattle WA 98195. e-mail: graham@isis.ee.washington.edu or Linda Shapiro, general chairman, (shapiro@cs.washington.edu).
- **June 18-20. International Ocean Technology Conference.** Glasgow, Strathclyde, UK. Contact: Claire Bowie, IOTC Organizing Committee, 9 Royal Crescent, Glasgow G3 7SP, Strathclyde UK, Tel: 041-332-0193.
- **June 19-20 ICORR '91 International Conference on Rehabilitation Robotics.** Atlanta GA. ***Sponsors***: Bioengineering Center, Georgia Institute of Technology ***Contact:*** Michael Burrow 404-894-7034.
- **June 20-22. 5th International Conference on Advanced Robotics: Robotics in Unstructured Environments.** Pisa ITALY. Sponsor: CNR (Nat'l Research Council of Italy} and others. Information: Prof. Paolo Dario '91 ICAR Secretariat, Consorzio Pisa Ricerche, Via Risorgimento 9, I-56126, Pisa Italy.
- **June 21-26 RESNA** 14th Annual Conference Kansas City Missouri. ***Contact***: Susan Leone, Dr. Mtgs. RESA, Suite 700, 1101 Connecticut Ave NW, Washington DC 20036, 202 857-1199.
- **June 23-28. EURISCON 91: The European Robotics and Intelligent Systems Conference.** Corfu, Greece. ***Contact:*** Prof. Tzafestas, National Technical University of Athens, Greece, Tel: +30-1-7757504; FAX: +30-1-7784578 or 6532023, or within the U.S. Prof. Kimon P. Valavanis, The Center for Advanced Computer Studies, University of SW Louisiana. Tel: (318) 231-6284; Fax: (318) 231-5791
- **July 8-12 International Joint Conference of Neural Networks.** Seattle WA. ***Sponsors:*** International Neural Networks Society and IEEE Neural Networks Council. ***Contact***: Sarah Eck, University of Washington Conference Management, IJCNN-91 Seattle.Tel (206)543-0888 or Fax (206)685- 9359.
- **July 29 First International Aerial Robotics Competition.** Atlanta, GA. Sponsor: Association for Unmanned Vehicle Systems Contact: Robert Michelson, Georgia Tech Research Institute, Aerospace Science & Technology Laboratory, Atlanta, Ga 30332
- **August 1-3. IEEE International Conference on Systems Engineering, Special Session on Reconfigurable and Reusable Real-Time Systems.**Wright State University, Dayton, Ohio. Session Co-Chairs: David B. Stewart, CMU (412)-268-7120 stewart@faraday.ece.cmu.edu and Thomas Wheatley, NIST, (301)-975-3449, wheatley@c-me.nist.gov.
- **August 5-6. International Conference on Integrated Manufacturing Systems and Processes.** Varanasi, India See *Calls for Papers.*
- .**August 9-14 Indo-US Workshop on CAD/CAM and Robotics.** Indian Institute of Technology, New Delhi INDIA See *Calls for Papers*.
- **August 1-3. AUVS '91: Unmanned Systems:Innovative Solutions for a Changing World.** Contact Richard Wagaman, McDonnell-Douglas, 1000 Wilson Blvd. Arlington VA 22209 703-248-3500.
- **August 13-15 1991 IEEE International Symposium on Intelligent Control** Arlington Virginia ***Sponsor:*** IEEE Control Systems Society. Contact: Prof. Alexander Levis, Dept. of ECE, George Mason Univ., Fairfax VA 22030-4444. Tel 703-764-6282.
- **August 16-18 International Conference on Simultaneous Engineering.** University of Roorkee, Roorkee, INDIA See *Calls for Papers*.
- **August 15-17, 1991**, Neural Networks for Ocean Engineering. Washington, D.C. ***Sponsor:*** IEEE Ocean Engineering Society in Cooperation with IEEE Neural Networks Council.
- **August 17-19**. Fourth World Conference on Robotics Research. Pittsburgh PA. ***Sponsor***: Robotics International of the Society of Manufacturing Engineers. ***Contact:*** Karen Kammerer, Conference Dept., SME, One SME Dr., PO Box 930, Dearborn MI 48121-9030. Tel. 313/271-1500, ext. 542.

•**August 19-22. 6th International Conference on CAD/CAM: Robotics and Factories of the Future. London UK.** Sponsor: International Society for Productivity Enhancement (ISPE). Contact: Dr. Michael Sobelewski, Concurrent Engineering Research Center, West Virginia University, Drawer 2000, Morgantown WV 26506, E-Mail: sobol@-cerc.wvu.wvnet.edu; Tel: (304)293-6961, ext. 115; FAX: (304)293-6888

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

• **September 10-12 2nd Gov't Neural Network Applications Workshop**, Huntsville ALA,. Sponsor: U.S. Dept. Defense Tri-service Neural Network Working Group. *(See Calls for Papers)*

•**September 30-October 2. ICDAR'91 First International Conference on Document Analysis and Recognition.** Saint-Malo, France Sponsors: CNRS, IAPR, IGS, INRIA, IEEE Section francaise Contact: Veronique Segaut or Corinne Sweeney, AFCET-ICDAR91, 156 boulevard Pereire, 75017 Pari s FRANCE, Tel: (33) 142679312 or Fax (33) 142679312:

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

•**October 22-24. 22nd International Symposium on Industrial Robotics** Detroit MI in conjunction with 6th International Service Robot Congress and the International Robots and Vision Automation Show and Conference. ***Sponsors***: Robotics Industries Association, National Service Robot Association, Automated Imaging Association, International Federation of Robotics (Stockholm, Sweden) ***Contact***: Robotic Industries Association. PO Box 3724 Ann Arbor MI 48106. (313)994-6088.

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

•**November 3-7. Active Materials and Adaptive Structures. Alexandria VA. *(See Call for Papers)***

•**November 18-21 IJCNN '91 Singapore. International Joint Conference on Neural Networks. *(See Call for Papers)***

•**March 16-18, 1992 2nd International Workshop on Advanced Motion Control** Nagoya Japan

•**May 18-22 1992. ECCV2 European Conference on Computer Vision.** Santa Margherita Ligure Italy. (***See Call for Papers)***

•**May 20-22, 1992 IFAC Symposium on Intelligent Components and Instruments for Control Applications.** Malaga, Spain. ***(See Call for Papers)***

•**July 13-15, 1992 Japan-USA Symposium on Flexible Automation**. San Francisco (***See Call for Papers)***

CALLS FOR PAPERS

•**International Conference on Integrated Manufacturing Systems and Processes.** August 5-6. Varanasi, India. Sponsor: Indo-U.S. Forum for Cooperative Research and Technology Transfer (IFCRTT) ***Deadline for abstracts:*** March 15, 1991. ***Contact:*** Dr. S. L. Malhotra, Director, Institute of Technology, Banaras Hindu University, Varanasi - 221005 India or Dr. Suren N. Dwivedi, Dept. of Mechanical Engineering, 333 ESB West Virginia University, PO Box 6101, Morgantown WV 26506, USA FAX 304-293-6689

•**Neural Networks for Ocean Engineering.** August 15-17, 1991. Washington, D.C. Sponsor: IEEE Ocean Engineering Society in Cooperation with IEEE Neural Networks Council. ***Submissions***:Send 5 copies of papers 8pp. or less before April 1, 1991 to CNNO Meeting Management, 5665 Oberlin Dr., Suite 110, San Diego CA 92121. Phone 619 453-6222.The program will include sessions on:

Passive Sonar Signal Processing	Active Sonar Signal Processing,
Ocean Monitoring and Modeling	Bioacoustics
Fisheries and Oil Industry Applications	AUV and ROV Applications
Underseas Communications	Underwater Image Processing.

•**Indo-US Workshop on CAD/CAM and Robotics.** Indian Institute of Technology, New Delhi INDIA August 9-14 ***Sponsor***: Indo-U.S. Forum for Cooperative Research and Technology Transfer (IFCRTT). ***Organizer:*** Dr. Suren N. Dwivedi, Dept. of Mechanical Engineering, 333 ESB West Virginia University, PO Box 6101, Morgantown WV 26506, USA FAX 304-293-6689

•**International Conference on Simultaneous Engineering.** University of Roorkee, Roorkee, INDIA.August 16-18 ***Cosponsors:*** International Society for Productivity Enhancement (ISPE), Indo-U.S. Forum for Cooperative Research and Technology Transfer (IFCRTT), and Indian Institute of Industrial Engineering (IIIE). ***Deadline for abstracts***: March 30, 1991. ***Contact*** Dr. Suren N. Dwivedi, Dept. of Mechanical Engineering, 333 ESB West Virginia University, PO Box 6101, Morgantown WV 26506, USA

•**2nd Gov't Neural Network Applications Workshop**, Huntsville ALA, Sept 10-12, 1991. Sponsor: U.S. Dept. Defense Tri-service Neural Network Working Group. The purpose of this meeting is to exchange technical information on neural network approaches to DOD/Government Problems. Sept. 10 session will be limited to those with a secret level clearance, Sept. 11-12 session requires only that participants be a U.S. resident. SUBMISSIONS: Send 3 copies of an unclassified (for both classified and unclassified papers) 800-1200 word summary by April 15 1991 to the Program Chairman, US Army Missile Command, Research, Development, & Engineering Ctr., ATTN: AMSMI-RD-WS-PO (Dr. John L. Johnson) Huntsville ALA 35898-5248 FAX 304-293-6689

•**2nd International IEEE Conference on Microelectronics of Neural Networks.** Munich. October 16-18, 1991. (Second Call) **Submissions:** Send five copies of a 3000-word abstract (not including figures) plus a cover page indicating title, author's name, affiliation, address and phone number should be sent by May 31 to Dr. Ulrich Ramacher, Siemens AG, Corp. R&D, ZFE ME MS 32, Otto-Hahn-Ring 6, 8000 Munich 83, Telephone: 49 89 636 41296, Fax: 49 89 636 41442. This conference is dedicated to hardware for neural networks and discussion of implementation constraints introduced by application, technology, and system environment. Categories for submissions include, but are not limited to: Potential Technologies, Hardware oriented modelling and simulation, VLSI adequate design of neural algorithms, System and chip architectures, CAD for neural chip design, Neural interfaces and sensors.

•**International Workshop on Intelligent Robots and Systems 91 (IROS'91)** Osaka, Japan, November 3-5., 1991(2nd Call) **Submissions**: Send 4 copies of an 800 word summary for review by March 31 to: Prof. Hirokazu Mayeda, Osaka University, Faculty of Engineering Science, Toyonaka, 560 Japan. Topics of interest include but are not limited to: Analysis for Robot Tasks, Task and Motion Planning, Robot Languages, Intelligent Motion Control, Hand-Eye Systems, Learning, Adaptive and Self-Organizing Systems, Neural Networks, Man-Machine Interface, Sensor Fusion, AI Techniques for Intelligent Robots and Systems.Phone: 81-6-844-1151(ext 4632); Fax 81-6-857-8664 E-mail: d63314a@ccsun01.center.osaka-u.ac.jp.

• **Workshop on Neural Networks in Robotics,** University of Southern California October 23-25, 1991 ***Sponsor:*** The Center for Neural Engineering at the University of Southern California. **Submissions: 3** copies of extended abstracts of proposed presentations (2 to 4 pages in length) by May 15, 1990 to Prof. George Bekey, Chairman, Technical Program Committee, c/o Computer Science Department, University of Southern California, Los Angeles, California 90089-0782 The goal of the workshop will be to stimulate discussion on the current status and potential advances in this field. The workshop will be concerned with (but not limited to) issues such as:

Connectionist approaches to robot control
Path planning and obstacle avoidance
Transfer of skills from humans to robots
Multiple interacting robot systems
Sensor fusion and interaction
Biological models for robot control
Combined machine/connectionist learning
Inverse kinematics and dynamics
Intelligent robots in manufacturing
Neural network architectures for robot control
Task learning by robots

•**Active Materials and Adaptive Structures.** Alexandria November 5-7, 1991. ***Sponsors:*** ADPA, AIAA,ASME SPIE and others. ***Focus:*** Civil and military applications of developments in active materials (including smart sensors and actuators), smart structures (including embedded avionics, micromotors, distributed processing, and artificial intelligence), and controlled structures technology. **Submissions**: Send an extended abstract of not less than 600 words by **April 13 1991** to Dr. Peter Dean, Lockheed Aeronautical Systems Co., Dept. 70-13, Bldg Unit 50, Plant 2, O Box 551, Burbank CA 91520, tel 805-295-4755 or Prof. Craig Rogers, Dept of Mechanical Engineering, VPI&SU, Blacksburg VA 24061. Tel 703 231-7194, e-mail rogers@vtvm1.cc.vt.edu. Full length papers can be simultaneously submitted to the Journal of Intelligent Materials Systems and Structures. Send full papers to Prof. Rogers or to Dr. Gareth J. Knowles, Mail Stop AO8-35, Grumman Corp. Res. Ctr., Bethpage NY 11714. Tel (516)575-3507. e-mail: knowles%crcvax@nssdca.span.nasa.gov.

- **IJCNN '91 Singapore. International Joint Conference on Neural Networks** Nov 18-21, Singapore. ***Sponsors***: IEEE Neural Networks Council and International Neural Networks Society. Papers may be submitted for consideration as oral or poster presentations in the following sessions:

Associative Memory	Electrical Neurocomputers	Image Processing
Invertebrate Neural Networks	Machine Vision	Neurocognition
Neuro-Dynamics	Optical Neurocomputers	Optimization
Robotics Control	Sensation & Perception	Sensorimotor Control Systems
Supervised Learning	Unsupervised Learning	Neurophysiology
Hybrid Systems (AI, Neural Networks, Fuzzy Systems)		Mathematical Methods
Applications		

Submissions: Send 8 copies incl. one camera-ready original of full papers of no more than 6 pages by **May 31 1991** to one of the following: ***USA: Ms. Nomi Feldman,*** IJCNN '91 Singapore, Meeting Management, 5665 Oberlin Dr., Suite 110, San Diego CA 92121, FAX: 619-535-3880; ***Japan: Prof. Toshio Fukuda***, Programme Chairman, IJCNN'91 Singapore, Dept. of Mechanical Engineering, Nagoya Univ., Furo-cho, Chikusa-ku, Nagoya 464-01,JAPAN, FAX: 91-52-781-9243 ; ***All other: Dr. Teck-Seng Low***, IJCNN '91 Singapore, Communication International, Associates PTE LTD, 44/46 Tanjong Pagar Road, Singapore 0208, Tel 226-2838, FAX: 226-2877, 221-8916

- **International Conference on Intelligent Control and Instrumentation (SICICI '92)** Singapore. February 18-21 1992. ***Sponsor:*** IEEE Singapore Section Control Chapter. **Submissions:** Four copies of 800-words abstract by 15 June 1991 to: Professor C. C. Hang, Technical Programme Chairman, SICICI '92. IEEE Singapore Section, 200 Jalan Sultan *11-03 Textile Centre, Singapore 0719. email: fenghcc@nus3090.bitnet

(Continued on back cover)

New Arrivals

Congratulations on receiving the Ph.D!

•Kenneth Y. Goldberg

August 1990 Carnegie Mellon University. Thesis: Stochastic Plans for Robotic Manipulation Advisor: Matt Mason. Current Position: Assistant Professor, CS and EE, University of Southern California Los Angeles, CA 90089

•Randy C. Brost

January, 1991, Thesis: "Analysis and Planning of Planar Manipulation Tasks", Advisor: Matthew T. Mason,- Current position: Sandia National Labs, Albuquerque, NM.

•Meyer Nahon

February 1991, McGill University, Thesis: "Optimization of Force Distribution in Redundantly Actuatied Robotic Systems. Advisor: Jorge Angeles

On the Move

Vladimir Lumelsky

To: Department of Mechanical Engineering,
University of Wisconsin
1513 University Avenue
Madison, Wisconsin 53706
TEL: 608-263-1659 or 6426
FAX 608-263-6707
e-mail: lumelsky@engr.wisc.edu
From: Yale University (Note: Until summer 1991 the address at Yale will also be operational.)

•Zuheir S. Tumeh

To: United Parcel Service
Research and Development
51-53 Kenosia Ave
Danbury, CT 06810-7317
Phone 203-731-5712
FAX 203-731-5712
From: General Motors

•Feiyue Wang

Current Employer:
Robotics and Flexible Manufacturing Laboratory
Department of Systems and Industrial Engineering
University of Arizona
Tucson, Arizona 85721
Telephone: (602) 621-8891
FAX: (602) 621-6646
Electronic Mail: feiy@tucson.sie.arizona.edu
Title: Assistant Professor

•Kenneth Y. Goldberg

To: University of Southern California
Los Angeles, CA 90089
From: Carnegie Mellon University

E-Mail Directory

Name	Affiliation	Email	FAX
Paul Fussell	Alcoa Labs	fussell@ncf.al.alcoa.com	
Philip L. Graves	Lockheed-ESC AT NASA-JSC	graves%lock.dnet@aio.jsc.nasa.gov	
Ten-Huei Guo	NASA - Lewis Research Center	ioguo@scivax.lerc.nasa.gov	216-433-8643
R. Place	Ball State Univ.	rlp@bsu-cs.bsu.edu	
Can Isik	Syracuse University	cisik@suvm.acs.syr.edu	(315) 443 2583
Ronny M. Blomme	State University of Ghent, Belgium	blomme@lem.rug.ac.be	++32+91 64 35 94
Jurek Sasiadek	Carleton University	sasiadek@carleton.ca	
Chun-Lung P. Chen	Wright State University	pchen%valhalla.wright.edu@relay.cs.net	
Edwin Hou	New Jersey Institute of Technology	Hou@hertz.njit.edu	
Kenneth Goldberg	University of Southern California	goldberg@iris.usc.edu	
Thomas Pendleton	NASA/Johnson Space Center	pendleto@aio.jsc.nasa.gov	713-483-3204
Steve Shafer	Carnegie Mellon University	sas@cs.cmu.edu	
Domenico Giorgio Sorrenti	Politecnico di Milano, Italy	sorrenti@ipmel1.elet.polimi.it	+39-2-2399.3587 or +39-2-2399.3411
Adam Smiarowski	The Catholic University	smiaronws%cua.bitnet@cunyvm.cuny.edu	
Tarek M. Sobh	Univ. of Pennsylvania, GRASP Lab	sobh@grasp.cis.upenn.edu	(215) 573-2048
Ye-Hwa Chen	Georgia Institute of Technology	mefacib@prism.gatech.edu	404-894-8336
Arati Suresh Deo	Rice University	arati@marsh.rice.edu	
Feiyue Wang	University of Arizona	feiy@tucson.sie.arizona.edu	
MengChu Zhou	New Jersey Institute of Technology	zhou@msaol.njit.edu	(201) 643-0674

From Roz Snyder, Managing Editor:

If you sent me your email address, it is not published here, and you would like it included in this directory, please let me know. If you sent me your email address before February 20 and you did not receive the e-mail version of the calendar, also let me know. Some of the addresses "bounce", sometimes regularly and for identifiable reasons, other times randomly or in accordance with the phases of the moon.

I am moving *June 9* to Winston-Salem North Carolina. After June 1, (and now, also) you can reach me via Wes Snyder at 919-748-3908 or e-mail *wes@sailboard.bgsm.wfu.edu* and he'll tell you where we've landed and plugged in my computer, telephone, and fax machine. Prior to June 1, address calls, correspondence and newsletter items to the address on the masthead.

Roz Snyder

Calls for Papers (Continued)

- **ECCV2 European Conference on Computer Vision.** May 18-22, 1992. Santa Margherita Ligure Italy. **Submissions:** Send long (~6000 words) or short (~2000 words) by **October 15 1991** to Prof. Giulio Sandini, DIST Univ. of Genova, via Opera Pia 11 A, 16145 Genova, FAX 39 10 603 801, e-mail eecv92@dist.unige.it. Topics of interest are Color, Texture, Stereo, Motion, Image Features, Stereo Motion Cooperation, Active Vision, Shape, Vision-based Control, Hardware Architectures, Applications. Proceedings will be published by Springer Verlag and a sections of the best papers will be published in Image and Computing Journal. There will also be a video proceedings.
- **1992 IFAC Symposium on Intelligent Components and Instruments for Control Applications.** Malaga, Spain May 20-22, 1992. ***Sponsor:*** International Federation of Automatic Control. **Submissions**: Send 5 copies of a 800-1000 word abstract (in English) by June 30 1991 to: SICICA '92, Facultad de Informatica, Plaza El Ejido s/n, 29013 Malaga SPAIN. (Tel:) (34)52-131412; FAX: (34)52-264270. E-mail: sicica@octima.uma.es.

1992 Japan-USA Symposium on Flexible Automation July 13-15, 1992, San Francisco. *Sponsors:* ASME and Institute of Systems, Control and Information Engineers of Japan. Submissions: Send four copies of long and short papers from all countries except Japan by November 15, 1991 to the Program Chairman, Professor Ming C. Leu, Dept. of Mechanical and Industrial Engineering, Rm. 311, MEC, New Jersey Institute of Technology, University Heights, Newark NJ 07152. A long paper is a complete manuscript including abstract; a short paper is 600-1000 word summary of research. Topics will include the following areas:

Robotics	Expert systems
Autonomous vehicles	CAD/CAM/CAE
Automated material processing and assembly	Artificial intelligence
Flexible manufacturing systems	Sensing and signal processing
Manufacturing process control	Reliability and malfunction analysis
Planning and scheduling for manufacturing	Communication and hardware systems
Mechatronics	

Position Available

The Center for Intelligent Robotic Systems for Space Exploration (CIRSSE) at Rensselaer Polytechnic Institute seeks applicants for the position of Research Assistant Professor.

This is a non-tenure track appointment in the Electrical, Computer, and Systems Engineering Department with research responsibilities in CIRSSE. CIRSSE is a NASA Unversity Space Engineering Research Center established at Rensselaer in 1988. The applicant should have demonstrated expertise in VsWorks, SILMA, dynamics and control of dual arm manipulators, and especially in the implementation of real time robot control systems including hardware and software. The development of the dual arm testbed is a major responsibility of this position. Responsibilities also include proposal writing and supervision of under-graduate and graduate students. A doctoral degree in a related field and U.S. citizenship is also required.

Applications or requests for more information should be directed to Professor Alan A. Desrochers, Associate Director, Center for Intelligent Robotic Systems for Space Exploration, CII 8015, Rensselaer Polytechnic Institute, Troy, NY 12180-3590.

RPI is an affirmative action/equal opportunity employer.

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