CENTRE FOR INTEGRATED COMPUTER SYSTEMS RESEARCH • C • I • C • S • R •

THE UNIVERSITY OF BRITISH COLUMBIA

FOCUS

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INDUSTRY RESEARCH

A look at some of CICSR members' work with industry, including Hughes and Motorola

Collaboration with industry is one of the main goals of CICSR, and it's working. At any given time, several CICSR researchers are at work on an industry-sponsored project, some out at the company site.

One example is the work Jeff Joyce is doing at Hughes Aircraft of Canada in Richmond. Since late 1989, Hughes has been at work on a $400 million contract to develop a new air traffic control system for Canada called CAATS. Hughes currently has some 400 people at work on what is

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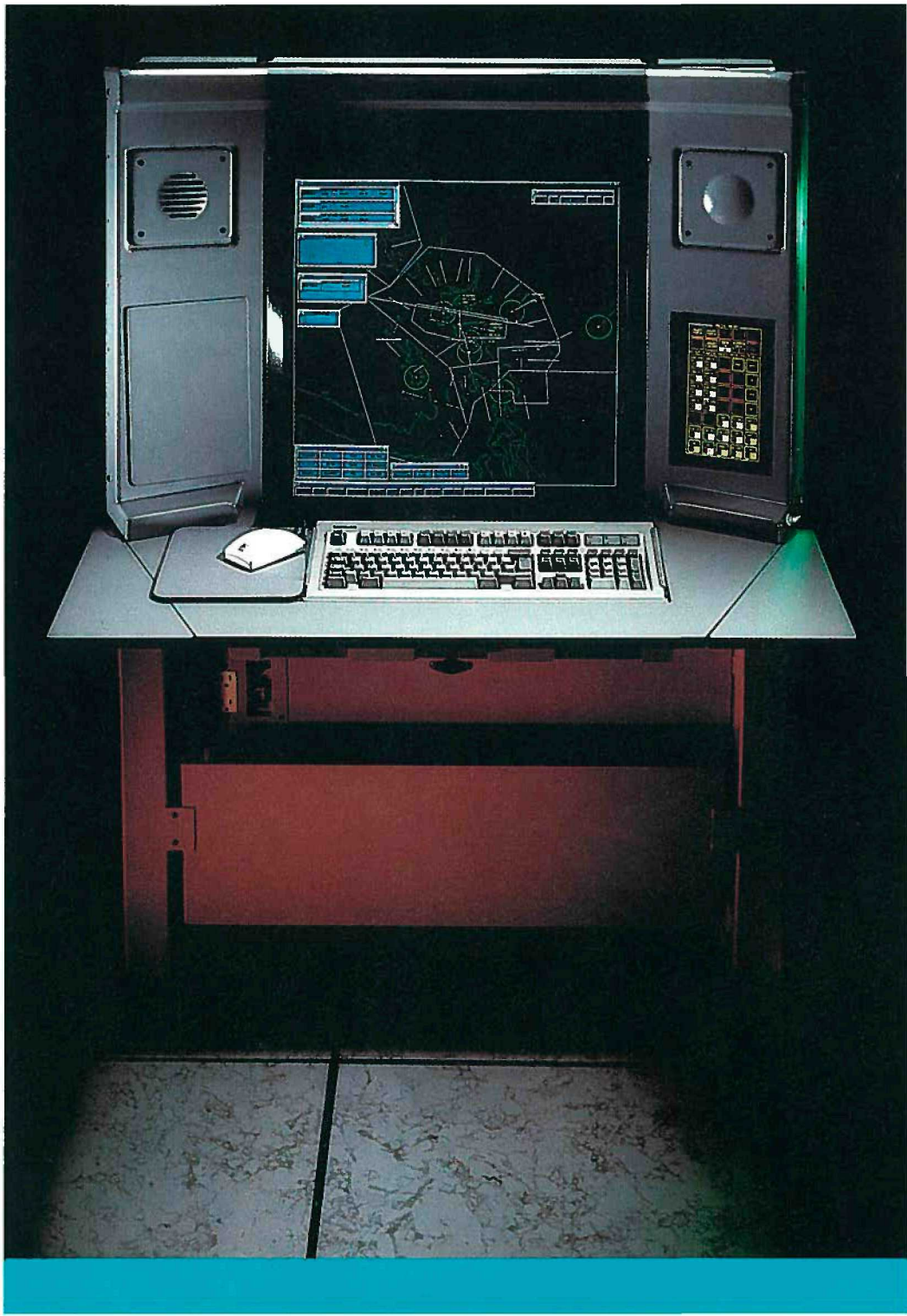

CICSR member Jeff Joyce is working on formal methods research as a way to improve requirement specifications at Hughes Aircraft.

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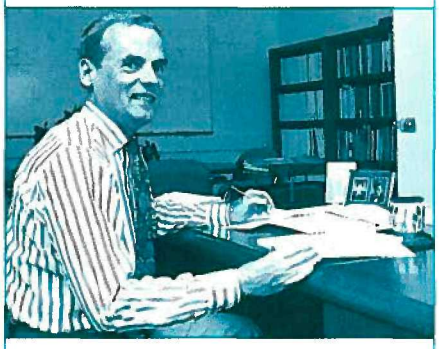
DIRECTOR'S STATEMENT

■ This Spring is being ushered in with a flourishing of CICSR research activity. Since moving into the new CICSR/CS Building last Fall, CICSR researchers have expanded their programs and collaborations dramatically.

New liaisons have been formed with industrial partners and academics at other institutions, facilitated by the research space available and the new funding mechanisms from NSERC and the B.C. Advanced Systems Institute, for example. Some of these are highlighted in this issue of the CICSR newsletter, including industrial collaboration projects between CICSR researchers and Hughes Aircraft and Motorola.

CICSR is also expanding its links with other academic disciplines, in particular



with the Faculties of Education (to pursue work on the E-GEMS project) and Commerce (to develop Meeting Place software). Both collaborative projects are described in detail in this newsletter.

All the speakers for next year's Distinguished Lecture Series are now confirmed. The series will focus on human-computer interaction, a topic of widespread interest among researchers in group dynamics and decision support systems for business use, and multimedia researchers in education and computer science. The series promises to provide a fascinating look at how we will interact with computers, both individually and in groups, in the future. ■

Dr. James Varah, CICSR Director

More than 500 of these Common Controller Workstations will be provided for the Canadian Automated Air Traffic System (CAATS). Photo provided by Hughes Aircraft of Canada

HUGHES ... continued from cover

reputed to be the largest software project in Canada. Under the Transport Canada contract, Hughes has been given the job to provide Canada with the world's most advanced air traffic control system. The project is a major challenge, but the skills developed by the Hughes team in Richmond have already been sought after by other countries seeking state-of-the-art air traffic control systems.

Joyce, a member of the Department of Computer Science at UBC, has been working half-time at Hughes since October to investigate possible applications of formal specification techniques to selected aspects of CAATS.

On any complex software project, a series of specifications are written outlining what the software is supposed to do. Once the developer and client agree on the specs, the work proceeds. In the case of CAATS, there is a whole bookcase full of requirement specifications generated. For each specification, code must be written and tested against the specifications. The task is complex, and Joyce believes, lends itself well to formal methods, his main area of research.

Joyce, with the help of several graduate and post-doctoral students, is rewriting some of the specifications in mathematical language that lends itself to formal methods, but is also readable by people who are not mathematicians. The reason for doing this is that math is a far more precise language than English. Another advantage, and fodder for more research, is that mathematical specifications could be used to automatically generate test cases.

Currently, developers test their software against the specifications by generating test cases for every possible scenario specified, and then testing the software against these cases. However, this method can be somewhat error-prone, especially for very complex specifications. As well, if the specifications change, re-doing the relevant test cases can pose quite a challenge.

"At this point, using formal methods to write specifications is an exploratory idea," said Joyce. It may or may not be implemented as part of the CAATS project. Joyce's goal is to develop a method of writing specifications that will mean less overall effort and better results for the software development team. He is keeping his approach general enough to be applicable to any software project.

In Hughes' case, Joyce is retrofitting an existing project, and it may not be appropriate to rewrite all the existing specifications into mathematical language. But he plans to take what he's learned, and possibly apply it in future Hughes projects or to the software development of other B.C. companies. Both he and the Hughes team will have learned from the experience. ■

CICSR research talents in demand at Motorola

UBC Electrical Engineering is a valued source of knowledge and talent for Motorola.

CICSR researchers are studying issues that will help in the development of the next generation of portable communications devices, including future generations of the Motorola personal data communicator (above).

The UBC Department of Electrical Engineering is no stranger to Motorola Canada. At its Richmond office, the international provider of wireless communications and electronic equipment, employs many of the department's alumni, and always seems to have one or more faculty at work on various research projects.

"The Electrical Engineering Department is an excellent bed of knowledge for us," said Bill Cooksley, director of Motorola's Advanced Radiodata Research Centre. He oversees the research agenda at Motorola's Richmond office, and arranges for outside researchers to fill gaps if needed.

Assistant professor Samir Kallel completed a study in the past year for Motorola entitled *RD-LAP Combining ARQ Schemes: How to enhance and improve the protocol.* Basically Kallel was interested in determining how code-combining can be incorporated into the RD-LAP communications protocol, and in quantifying its effect on performance. Using the existing protocol, an entire packet is discarded if it contains errors, even if some useful information was transmitted. Kallel looked at ways for the system to understand it received good information as well as some jumbled data, to distinguish between the two, and request that only the damaged data be re-sent. For example, if ten packets of information are sent as part of a transmission, and all but one are error-free, Kallel would like the system to be able to send back a message requesting a re-send of the damaged packet only, not the whole works.

This research has the potential to dramatically increase wireless communications efficiency, but it's a study for the future, according to Cooksley. If what Kallel is doing appears to work well, it may be incorporated in Motorola products of the future. In general, Motorola tends to use university researchers for long-term projects, said Cooksley, because they have a greater opportunity than Motorola's engineers to focus on specific areas of technology, but can't always react fast enough to work on time-sensitive projects.

Cyril Leung, another member of the Electrical Engineering Department, has worked on research for Motorola in the past, and is now employed at Motorola on a research project about which Motorola is currently not releasing information. Leung's past project involved providing his opinion on Motorola's analysis of future high-capacity wireless networks. Some of the resulting paper, a joint effort between Leung and Motorola's research staff, may be published in the future.

Victor Leung of the Electrical Engineering Department has also completed research for Motorola. The project was jointly sponsored by B.C. Tel Mobility Cellular, Motorola and Science Council of B.C.'s Technology B.C. program. The title of the resulting study is, "Integrating Packet-Switched Data Service to Circuit-Switched Service in Cellular Mobile Radio Networks."

The research concerns the new technology dubbed CDPD (Cellular Digital Packet Data), which will enable digital data communications over cellular networks. A simple application of this technology is the sending of faxes from laptop computers. Cooksley notes there are several challenges in relation to this technology. Leung's work involved looking at performance issues, and studying how the technology will work in the real world once it is deployed.

"We don't have the bodies here to look at all the issues we want to study," said Cooksley. So he determines which projects he should hand off to be tackled by outside researchers, who are often CICSR members. "It's a slow process to determine which projects are useful to both Motorola and UBC, but we envision more projects in the next six months."

Cooksley said the advantages of using CICSR researchers in conjunction with Motorola's internal research staff is that it provides the company with a different perspective, and provides access to a talent pool consisting not only of faculty researchers, but also students who may go on to work at Motorola after graduation. The relationship also enables Motorola to invest in longer-term research that may not be applied until several years down the road. Being a product-oriented company, Motorola can't afford to puts its own engineering staff to work on the longer-term issues, said Cooksley.

The major drawback to working with university staff is the issue of intellectual property ownership, according to Cooksley. University policy is to retain ownership of the work of its staff, and license the technology out to companies. This arrangement might work for some technologies, but companies prefer to own key technologies outright. In Motorola's case, the issue is side-stepped by having only staff members work in key research.

Overall, the advantages outweigh the drawbacks, which is why Cooksley expects more CICSR and Motorola collaboration in the future. He adds that sabbaticals are great for allowing university researchers to time to work on-site. "There's a great exchange of knowledge if we can bring the researcher to the company site," said Cooksley.

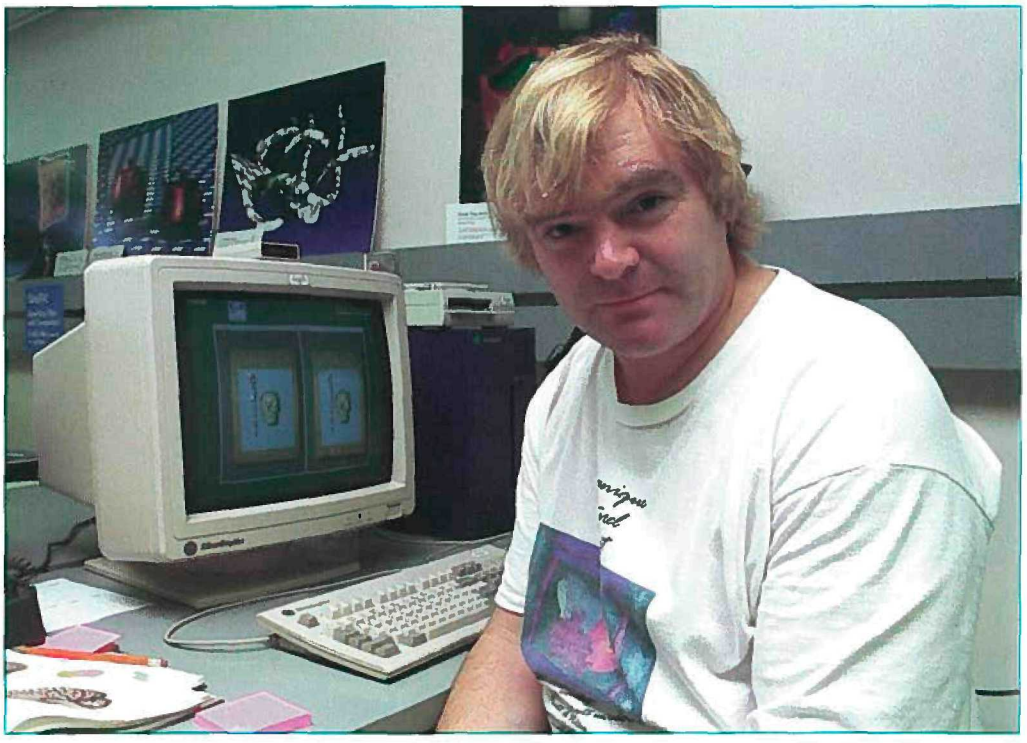
Building a haven for research labs

The new CICSR/CS building facilitates new and expanded collaborative research in many areas, including the Imager Lab projects described below.

With the new CICSR Building complete, and new laboratories in place, researchers are working on many collaborative projects that some say would not have been possible without the new facility. With its light, open spaces, and sophisticated communications capabilities, the new building lends itself to creative collaborative research.

One project facilitated by the new building is Peter Cahoon's work using visual systems as a tool to aid doctors and dentists performing facial reconstructive surgery. The work takes place in the Imager Lab, which has state-of-the-art imaging equipment that is in use around the clock.

A major coup for the lab is that as part of this project, which is a collaborative project with University Computing Services, they have connected the first active link using ATM (asynchronous transfer mode) technology. This exciting new communications medium allows for real-time transfer of video, images, voice and more data than ever before. As Imager Lab director Kelly Booth notes, it has been possible to send data over phone lines for a long time, but not at the rate required to move very large image files across a network, and enable viewers at both ends to look at the same image simultaneously.



Peter Cahoon is developing visual tools in the Imager Lab to facilitate facial reconstructive surgery.

The ATM link is between the UBC Radiology, Craniofacial Biology and the Imager Lab, and will facilitate work in developing visual tools for surgical planning for facial reconstructive surgery. Cahoon is also working with B.C. Children's Hospital and the RCMP on various aspects of imaging for facial reconstruction. Surgeons are interested in being able to predict how facial surgery will affect young patients as their bodies grow and mature. The RCMP are interested in the technology to develop realistic portraits of missing children when no current photo has been available for years. Using available data, and known growth patterns, a preliminary study is looking at the feasibility of an imaging system to show realistic portraits over years of development.

It's a very complex problem which requires using data from various sources, including scans that show bone structure, surface information, and skin and muscle information, and determining the feasibility of integrating all three into a single model. It's a difficult problem, but there are a lot of people who could make use of the solution.

Rabab Ward of Electrical Engineering is also at work on imaging problems using the resources of the Imager Lab. She is working with Rogers Cable TV to improve the picture quality and reduce noise in images sent via the cable network. The research, funded by NSERC and Rogers Canadian Cable Labs Fund, has promising applications in the medical field as well.

Some of the projects Ward and her research team are currently working on deal with: developing a monitoring system for cable TV pictures; developing a non-intrusive system to measure the parameters of cable TV; developing and building prototypes for canceling impairments and noise arising in the cable TV signal; and developing schemes for reconstructing images blurred by atmospheric turbulence.

The research into image processing also has applications in other areas. For example, one current project involves developing schemes for restoring mammographic images so that early signs of cancer are automatically detected. Another looks at developing noise-resistant compression schemes for high-definition television.

Rabab Ward of Electrical Engineering focuses on improving image quality for cable networks.

Video games for math and science instruction

The E-GEMS project focuses on using electronic games to teach math and science to children

Learning math and science isn't fun and games to most young students, but a multidisciplinary project at UBC has plans to make it that way. Led by Computer Science Department head Maria Klawe, with input from a large and varied group of researchers, E-GEMS (Electronic Games for Education in Math and Science) is aimed at developing computer games that spark interest in, and/or help children understand, math and science concepts.

While there is some resistance on the part of parents and teachers to video games, there is no denying they have captured the imagination of today's children. Nintendo is now a household world. What Klawe proposes is that rather than ignore this fact, educators should capitalize on it by developing games that teach children while they entertain. She and other E-GEMS project members believe computer games should be part of the school curriculum for intermediate grades. As an example, Klawe has led the development of Monkey Math, a collection of prototype games and activities to help kids learn the concepts of negative numbers and fractions, topics they tend to have trouble with. This is a small start compared with the large vision behind E-GEMS.

The people involved in the project are a diverse bunch, including: Computer Science grad students Kori Inkpen, Rob Scharein, Kamran Sedighian, Richard Dearden, and post-doc Joan Lawry; Psychology Ph.D. student Kelly Davidson; Ann Anderson, a member of the Education Faculty at UBC; Rena Upitis, an associate professor of Education at Queens University; Kelly Booth head of MAGIC at UBC; and Computer Science undergraduate students David Hsu, and Steve Leroux. As well, employees of Electronic Arts, a multinational computer game developer, are working on some pieces of the puzzle, making it a truly interdisciplinary project.

There are many facets to the project, which is growing all the time. According to project researcher Rena Upitis, E-GEMS is a true university-industry partnership between the researchers and Electronic Arts. "What they're developing, we research, and what we research, they develop. It's a two-way street, a true partnership."

As the world's largest electronic game developer, Electronic Arts is very interested in the education market, and in making games that help kids learn. In Klawe's vision, there is another aspect as well — the fact that girls seem to be turned off of math and science in greater numbers than boys. As part of the project, she'd like to see games developed that spark the interest of girls in math and science.

E-GEMS researchers (from left) Richard Dearden, Rena Upitis, Kori Inkpen and Nic Thorne.

As part of Kori Inkpen's Ph.D. thesis, she is studying part of this problem. Inkpen is studying collaborative play amongst school children using computers. Her preliminary results show that pairs of girls perform better when they share one computer, and worse when they each have a computer of their own. This raises questions about current computer game design — games are usually one-player scenarios, and if there are two players, they are usually competing. Possibly games may appeal more to girls if there was provision for two people to play on one computer as a team.

This is one of countless questions that could be answered during the course of E-GEMS. Rena Upitis is interested in spatial visualization problems, and is studying how children learn using a variety of media, from computers to video to paper models. Preliminary results show children may have a preference for the computer, and may learn better with computers, but more work needs to be done to reach firm conclusions.

Another long-term goal of E-GEMS is research that may help keep some children interested in school who are currently dropping out. "Through the popular culture of electronic games, we may be able to help kids become more interested in math and science," said Upitis. I feel it's a mistake to ignore the popular culture. Perhaps if school and life weren't so separate, more kids would stay in school."

Other questions the group is studying include: how to make computer games more "girl-friendly"; what configuration of computer system works best for children and learning; what are the effects of different environments such as the home; how is learning affected if a parent or teacher works with students; how do educational computer games work with various learning styles... and more.

According to Upitis, the team is keeping the focus broad, and its numbers are increasing all the time. Last summer some 15,000 children took part at a Science World exhibit as part of the E-GEMS project. Studies are also taking place in various schools, to include representation from kids of varying race, background and socio-economic status. As Upitis notes, "There's lots to do," but the group isn't limiting its scope because of the sheer magnitude of the task. Instead E-GEMS is structured to grow and expand as needed to answer the important questions about how computer games can help kids, especially girls, become interested and stay interested in mathematics and science.

Robots that play soccer

The Laboratory for Computational Intelligence has developed robotic cars that can autonomously play a game of soccer.

Robot soccer researchers (from left)Alan Mackworth, Rod Barman, Stewart Kingdon and Michael Sahota at work in the Laboratory for Computational Intelligence.

■ It may look like fun and games in the Laboratory for Computational Intelligence, with radio-controlled cars whizzing around a table after a bright pink ball, trying to shoot it into each other's goal. But in fact, enabling these robotic cars to engage in a simple game of soccer is a very complex research task.

The real challenge of the project, according to Computer Science graduate student Michael Sahota is enabling the cars to respond in real-time to a dynamic situation. If you scaled the radio-controlled cars used in the lab up to life-size, their scale speed would reach 120 kilometres per hour. "The fact that we're able to control them at this speed is quite a triumph," said Sahota.

The research project encompasses many areas of research and development, and was initiated by professors Alan Mackworth and Dinesh Pai. Called, Dynamo (Dynamics and Mobile Robots), the research project is funded in part by IRIS (Industrial Robotics & Intelligent Systems) Network of Centres of Excellence, NSERC and the Canadian Institute for Advanced Research.

Sahota's contribution is focused on providing the robots with the necessary intelligence to play a game of soccer. The robots are programmed with several playing modes, including offense, defense and goal. There are many factors that go into deciding which mode to play in, including the positions of the player, the ball and the opponent. If these were static, the problem might not be so complex, but when all three are moving, the robots have to be able to "think" at the same time as they're acting. This is an area that needs a lot of work, said Sahota. Most robots in use today work in static environments. They think, act, then stop to think again. This would make for a rather slow soccer game.

In addition to artificial intelligence research, work had to be done in computer vision and tracking to make the robotic soccer game possible. The cars are marked with large coloured circles, and are tracked using a video camera mounted above the testbed, a raised playing field, with a lip around the edge to contain the game. The camera is connected to a special-purpose vision-processing computer which sends commands back to the car via radio signals. The cars are standard radio-controlled cars.

At any given time, about eight professors, students and staff are at work in the lab on various aspects of the project. For example, Alan Mackworth, Rod Barman and Stewart Kingdon designed the colour tracking system, which has attracted serious commercial interest (see sidebar). Dinesh Pai of the Department of Computer Science has specified constraints for the cars' motion. These constraints are used to help the cars plan their path. Given their turning radius, and the size of the board, it's not always a simple straight line for the cars to get to their target.

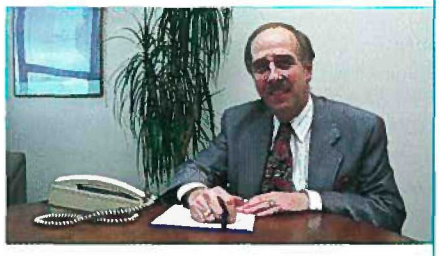
Sahota notes that the problem of robots playing soccer has not yet been perfectly solved. There are times when both cars get hung up, and sit there looking as if they're unsure of what to do next. However, the research team is charging ahead by adding even more complexity: two cars per team. Sahota expects it to be a real challenge getting two cars to co-operate in a dynamic environment. However, the applications of the knowledge that will result from this research could be far-reaching, and far more serious than a simple game of soccer. ■

New Ties with Industry Liaison

■ CICSR and the UBC Industry Liaison Office established closer ties recently, as Doug Gill, Networks Centres of Excellence Technology Transfer Manager, set up his office in the new CICSR building temporarily. During his five-month stay, Gill helped negotiate a licensing agreement for technology developed in one of CICSR's labs, and helped make a case for the decentralization of the Industry Liaison Office.

The Industry Liaison Office works with UBC researchers to protect their intellectual property through patents, copyright and trademarks, and negotiates the licensing of technology to industry. The Office also negotiates the terms and conditions to all research contracts involving UBC staff and industry.

"The Computer Science and CICSR area is an excellent area in which to consider establishing closer ties," said Gill. "With an Industry Liaison staff member on-site, we can offer better service." While there



are no immediate plans to locate another Industry Liaison staff member at the CICSR building, the experiment was successful enough that such a move may be considered in the future.

While at the CICSR building, Gill helped licence the Dynatrack colour tracking system to an Ontario-based Cognitiative Systems. The tracking system was developed in the Laboratory for Computational Intelligence to track the motion of robotic cars. The technology has applications in any field where tracking with a video camera system is desired, from manufacturing to virtual reality. ■

Meeting Place

The MIS Division has developed software that will help facilitate the meetings of the future.

Many people in today's business world regard meetings as a necessary evil. It is necessary for groups of people to meet to brainstorm, plan and reach consensual decisions. But many business people regard meetings as the biggest time-waster in their day. Research being done at the UBC Faculty of Commerce may change this.

The Management Information Systems (MIS) Group, with the help of UBC Computer Science graduate students, has developed software called Meeting Place, which facilitates meetings, helps groups arrive at decisions, brainstorm, vote, plan, and more easily carry out all meeting functions. The goal is to use the software to study the dynamics of business meetings and determine how the dynamics change when computers are used as meeting tools. However, to date, most of the effort has been spent developing the software.

Meeting Place is now a fully-functioning software package, with a seamless user interface that Commerce associate professor Bob Goldstein finds superior to commercial products on the market. The software runs on the NeXTStep operating system, and includes modules for messaging, conferencing, brainstorming, ranking ideas or candidates, voting, resource allocation, and idea clarification. The software also includes modules to preconfigure meetings ahead of time, and to log meeting events.

Development of Meeting Place began in 1992, and the software is now fully functional, and ready to run meetings. It has commercial potential, although that is not the focus of the developers at the moment. Goldstein and MIS Division assistant professor Andrew Trice are exploring the possibility of adding more features, and planning their research strategy.

Goldstein has tried out the current commercially-available meeting software and found the experience "interesting." However, he found the software he used was not flexible enough to allow the meeting to flow naturally. He was always very aware of the software. Meeting Place will be different, he said. The goal is to make the software so flexible, it is an aid that enables meeting groups to reach their goals more quickly, but it doesn't get in the way of what the group wants to do.

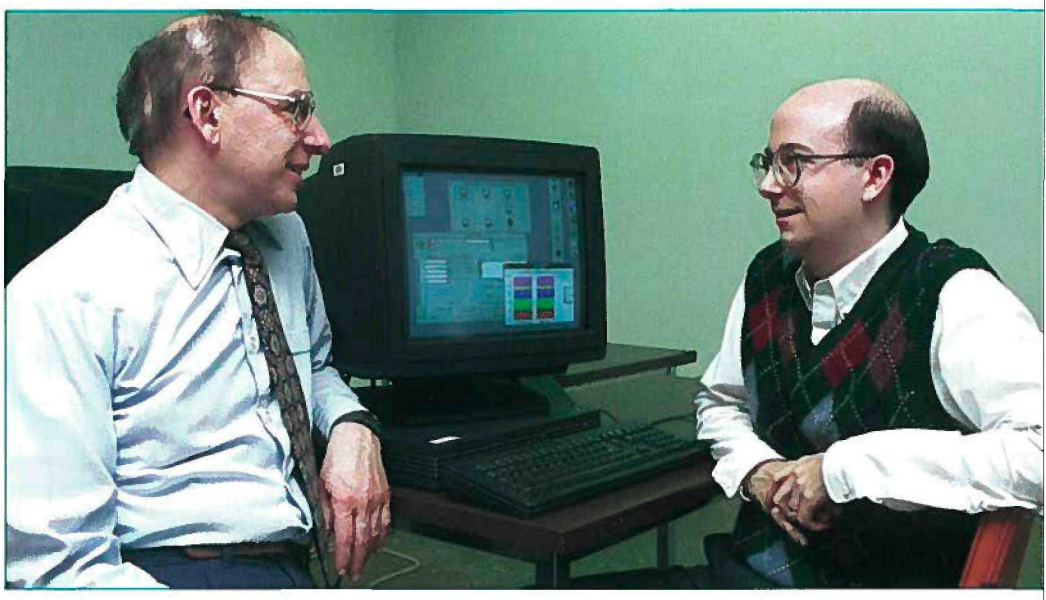
However, even with the limitations of the current software on the market, users report being more satisfied with the decisions arrived at during computer-assisted meetings. The software helps build consensus. That could be because in computer-aided brainstorming sessions, ideas are anonymous, so they are judged on merit alone, and not weighted because of their source. As well, the computer offers an impartial, fair way of tabulating the input of all members at the meeting, and can calculate a true picture of the overall group feeling on a subject. (whereas in today's meetings, "group" decisions are often made by the most powerful, and most vocal people present).

Meeting software developers also claim better productivity and better decisions as a result of meetings held using their software. However, these claims have yet to be scientifically proven. This is a key area of research that Meeting Place was developed to facilitate. The software definitely changes the dynamics of meetings. The question is does it change them for the better, and if so, how? Are there situations that lend themselves to computer-assisted meetings and others that work better the old-fashioned way? These are the types of questions future research at the MIS Division will answer.

In the meantime, work continues on the software. The possibilities are endless, but the types of features Goldstein and Trice are considering give us a glimpse of what might constitute a meeting of the future. For one thing, meeting participants won't all have to be in the same physical place. Meeting Place is already set up in a limited way for distributed meetings, and more functionality will be possible in the future. Another possibility is that people won't all have to attend the meeting at the same time. The software can make "virtual" meetings possible, a real benefit to multinational companies operating in different time zones.

Trice also envisions superior after-meeting support. The system already logs events during the meeting. Given this, minutes could be automatically generated, even tailored to each meeting participant, with their own action items flagged. The Meeting Place team is also looking at more in-depth logging. They are exploring with Kelly Booth of the Department of Computer Science, the possibility of videotaping meetings, and marking places in the tape where specific events occurred. So if, for example, a person not present at the meeting wanted to see what happened right before a key decision was made, he could specify the event recorded by the software, and have the tape advance to that spot automatically.

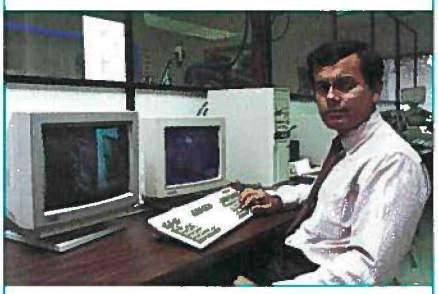
Possibilities for the software abound, but in the meantime, the MIS Division is hoping to construct a meeting room for business to try out the software's current capabilities. They have plans for a high-quality board-room, with computer screens recessed into the tabletop running Meeting Place software. The interest from the business community is high, said Goldstein. They hope to find corporate sponsors interested in helping put Meeting Place into action. Once the meeting room is set up, the meetings can be monitored and the results can help advance our knowledge of the benefits of meeting-facilitation software.



Bob Goldstein (left) and Andrew Trice of the Faculty of Commerce, MIS Division.

PASSING NOTES

De Silva first Canadian to chair ASME committee



■ Mechanical Engineering professor Clarence de Silva has been chosen to chair the Expert Systems and Artificial Intelligence Committee of the Dynamic Systems and Control Division, American Society of Mechanical Engineers (ASME). He is the first person to serve in this position from outside the U.S.

De Silva has also recently been awarded a Killam Memorial Faculty Fellowship for the 1994/95 academic year. He will spend a sabbatical year at University of Oxford and National University of Singapore, and with the Killam Fellowship, will carry out research on the integration of intelligent sensors into automated processes.

De Silva is chair of the B.C. section of the ASME and is also chair of the Control Systems Society of the Vancouver section of the Institute of Electrical and Electronic Engineers (IEEE). He is also the Natural Sciences and Engineering Research Council professor of industrial automation in the Dept. of Mechnical Engineering.

Alain Fournier to receive CHCCS Achievement Award

UBC Computer Science professor Alain Fournier is the recipient of a major award from the Canadian Human-Computer Communications Society (CHCCS), which groups people interested in computer graphics and user interface technology.

Fournier will receive the award at the May Graphics Interface Conference in Banff, the longest-running regularly-scheduled computer graphics conference in the world. The award recognizes career acchievement in computer graphics and interface research. ■

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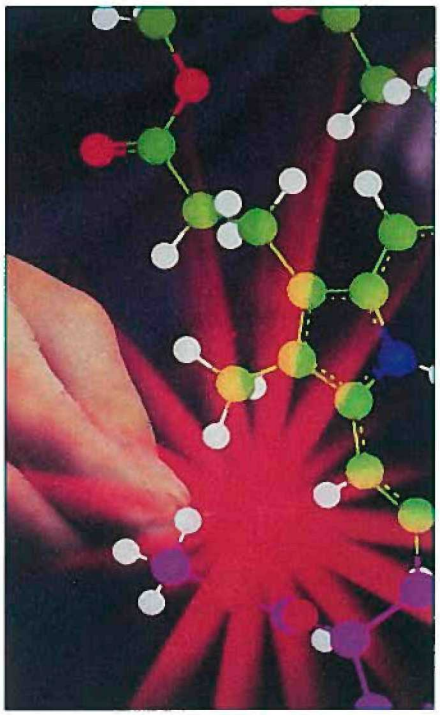

Distinguished Lecture Series 1994-95
Window to the Future
Six academic and industrial leaders address the changing face of human-computer interaction.

September 22, 1994
User Interfaces for information visualization dashboards and roadmaps for the Information Superhighway
Dr. Ben Shneiderman
University of Maryland

October 13, 1994
Groupwork and Groupware: How the process and product of real-time group work changes with shared workspaces and long-distance connectivity.
Dr. Judith Olson
University of Michigan

November 10, 1994
Collaborative Multimedia and Multimedia for Collaboration
Dr. Ronald Baecker
University of Toronto

January 12, 1995
Continual Improvement Software: A Case for Progressive Problem Solving
Dr. Marlene Scardamalia
Ontario Institute for Studies in Education

February 9, 1995
Work-Oriented System Design
Dr. Lucy Suchman
Xerox Palo Alto Research Center

March 9, 1995
"Being There" in Virtual Space
Dr. Thomas Furness
University of Washington

CICSR is hosting its sixth annual Distinguished Lecture Series, bringing in academic and industrial leaders in the forefront of their respective fields.

This year, DLS speakers will be discussing the changing human-computer interface, and looking at new ways individuals and groups interact with computers to access information, solve problems and more.

Join us for a Glimpse of the Future of Human-Computer Interaction

Lectures are from 4:00 pm to 5:30 pm, in the new CICSR/CS Building, Room 208, 2366 Main Mall, UBC. Lectures are complimentary.

CICSR:

The UBC Centre for Integrated Computer Systems Research (CICSR) is an interdepartmental research organization made up of computer-related research faculty members in the Departments of Computer Science, Electrical Engineering and Mechanical Engineering. Currently there are more than 60 CICSR researchers which direct over 200 graduate students and collaborate with dozens of industrial firms in areas such as robotics, artificial intelligence, communications, VLSI design and industrial automation.

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