CICSR
CENTRE FOR INTEGRATED COMPUTER SYSTEMS RESEARCH

FOCUS

THE UNIVERSITY OF BRITISH COLUMBIA

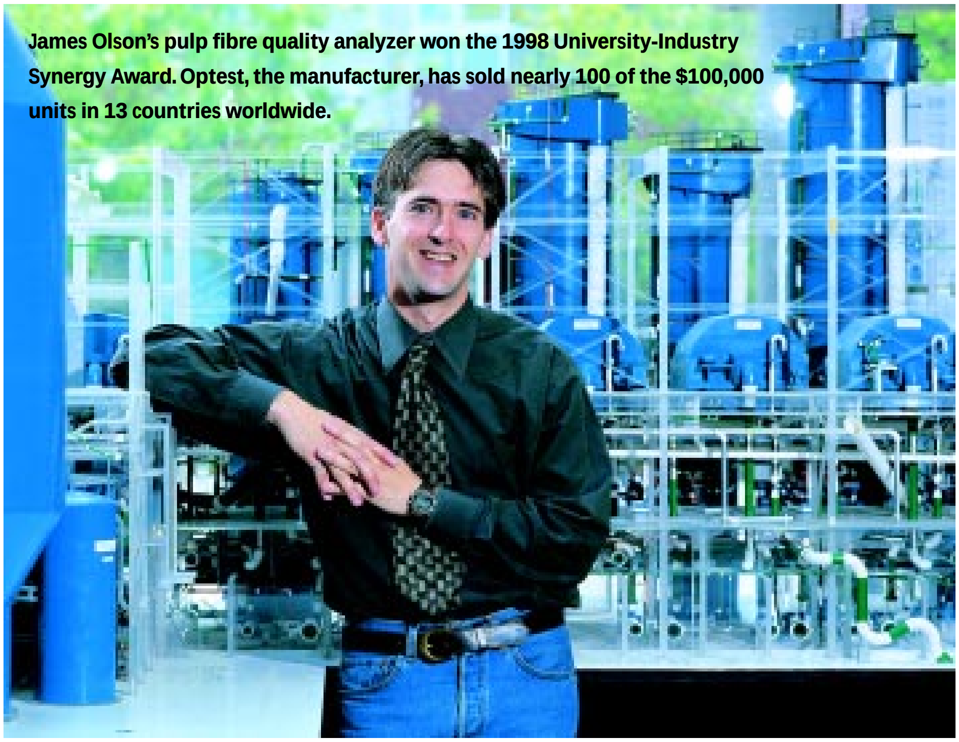
Advancing Technology for Pulp and Paper Manufacture

By studying the physics and fluid mechanics of wood fibres pulp and then developing computational equations to simulate how pulp is processed, James Olson aims to make BC's largest industry more profitable.

When we un-jam paper from a printer, or hold up a sheet of bond to examine its grain and texture, we don't usually consider the contribution each individual fibre makes to paper quality and durability. Recently appointed a faculty member in Mechanical Engineering, a position funded by the Advanced Papermaking Initiative (API), James Olson spends most of his working hours thinking of nothing but.

"The forest industry is the largest industry in BC by far. It represents 48 percent of our gross domestic product, and 20 percent of that is pulp and paper," says Olson. "The pulp and paper industry is also the single largest chemical industry in BC."

With assistance from API, which is supported by an $8.5-million endowment from Forest Renewal BC, Olson is able to devote his time solely to researching and teaching new technologies for the manufacture of pulp and paper.



James Olson's pulp fibre quality analyzer won the 1998 University-Industry Synergy Award. Optest, the manufacturer, has sold nearly 100 of the $100,000 units in 13 countries worldwide.

Fibre quality analyzer

Olson is no novice to the intricacies of papermaking. He developed a fibre quality analyzer that has now become the industry standard. UBC and Paprican jointly patented the device, which has a specially designed flow cell, a unique optical system, and simple, touch-screen technology. Olson also developed the algorithms to run the analyzer, which measures the length, shape and concentration of fibres. The device is very fast and able to analyze seven fibres per image at 100 images per second (the initial model ran on a 486 processor). A better determination of pulp quality means more quality control in paper manufacturing.

Paprican is the UBC Pulp and Paper Centre's largest supporting organization,

continued on page 2

CICSR
Director's Corner

This issue of *FOCUS* is particularly exciting because it features how UBC and CICSR are reversing the brain drain. Of the six new faculty members hired, four have been recruited from the US, and all are top researchers in their field.

Cristina Conati is from the University of Pittsburgh, where she began her research on intelligent systems for computer-aided learning. Anne Condon, an expert in computational complexity and DNA computing, came to us from the University of Wisconsin. Gregor Kiczales left his position as principal scientist with Xerox Parc in Palo Alto, CA, to assume the new NSERC-Xerox Canada-Sierra Systems Industrial Research Chair to further his work on aspect-oriented programming. Karon MacLean has pioneered the field of haptics at MIT and in Silicon Valley. They all cite the strength of Computer Science at UBC, the cooperative nature of research in Canada, and the quality of life here as their main reasons for making the move.

Also welcome to Kendal Bushe and James Olson, two other excellent new CICSR members who have joined Mechanical Engineering (ME). Their respective research in turbulent flows and fluid mechanics has exciting industrial applications. We will have six more new CICSR members (three from ECE and three from CS) joining us this fall. Watch for their profiles in upcoming issues of *FOCUS.*

Rabab Ward, CICSR Director

Olson: continued from page 1

and it is a prime example of industry–university collaboration. Olson has the stats at his fingertips. "Most people don't realize that 85 percent of the $1.17 million in annual funding the Centre receives from Paprican comes directly from pulp and paper manufacturers across Canada."

A major part of his research has been working with Paprican and CAE to build systems simulation tools for designing and optimizing the screen systems used in pulp and paper processing.

Improving screen plate technology

At first glance, a screen plate looks like a relatively simple device—a piece of metal with a slot cut into it. While they were originally designed to filter contaminants—a process called fractionation—the screens also separate out longer fibres. Screen plate manufacturers like CAE try to find a slot shape that filters contaminants and allows fibres to pass through without excessive clumping or plugging.

James Olson: "You can't have a successful forest industry without a successful pulp & paper industry, because all of it comes from chips, or residue from the solid wood."

Part of Olson's work is to use computational fluid dynamics to try and design the best screen shape. However, he notes that current screen technology doesn't take advantage of the fractionation process to try and separate the smoother, thinner and more flexible early wood fibres from the coarser late wood fibres. These create huge gaps, or weaknesses, in the paper making it too rough to provide good printing quality.

For Olson, the real challenge is in modelling how fibres flow in a turbulent fluid in order to determine how they would interact with the screen plate surface, and then to create the equations to represent this flow.

"The interaction between fibre and fluid is what goes beyond computational fluid dynamics. Any application will be a large-scale computational problem," says Olson. Obviously, he is ready for the challenge.

Contact James Olson at olson@mech.ubc.ca and (604) 822-5705.

Please join us on September 28, 2000 for the first DLS speaker of the year: Michael Lipsett. Lectures are free and start at 4:00 in room 208 of the CICSR/CS building, 2366 Main Mall, UBC. Michael Lipsett is with Syncrude Canada Ltd., and his talk is entitled "Intelligent Industrial Automation: Matching Research Programs to Technology Development Needs." *(See page 8 for a complete DLS schedule.)*

Using Intelligent Systems to Facilitate Learning

Cristina Conati uses artificial intelligence (AI) techniques to develop better ways to use computers to model—and assist—the learning process.

How do we learn? What motivates individuals to solve problems and why are some better at it than others? Today, it is not only educators and psychologists who are asking these questions. Experts in AI, such as Cristina Conati, are designing systems that can monitor users' interactions and respond in an adaptive way to individual strengths and weaknesses, in order to make the learning experience more engaging and effective.

Cristina Conati is a new member of CICSR and UBC's department of Computer Science.

Andes: encouraging self-explanation

Conati started working on AI at the University of Pittsburgh, where she completed her MSc and PhD in the Intelligent Systems program. There she participated in the development of the Andes Project—an intelligent tutoring system for Newtonian physics. As part of the project, Conati developed the SE-Coach, a framework to encourage self-explanation, the process by which students explain problems to themselves without the aid of an instructor. Self-explanation is usually more effective than explanation provided by others because it triggers active learning. In other words, a passive learner has more difficulty understanding and solving a problem, and is not as apt to experience "eureka—I've got it" revelations.

Unfortunately, most students do not self-explain unless prompted, notes Conati. The SE-Coach monitors students as they study with the interface. It then builds a model of how students understand examples, and stimulates them to build self-explanations that improve this understanding.

Adaptable interfaces

Designing interfaces that dynamically adapt to the user's level of knowledge and understanding is an important area of Conati's work, and it has applications in all types of intelligent systems. If the interface is too complicated, or interrupts the user too frequently, it can add too much overload to the user's task and therefore impede rather than stimulate it. To evaluate the SE-Coach, Conati had first-year physics students use the system to study physics examples. The students were from four different colleges, and some had started the semester earlier than others. One of the observations Conati made was that those who had spent more time studying a topic learned better on a simplified version of the SE-Coach, even though the results of testing prior to using the system showed they had the same level of knowledge as the others.

"One of the goals of my research is to devise computational models of teaching & learning that improve meta-cognitive skills such as self-explanation, self-monitoring, self-questioning, & learning by exploration."

"They didn't know more, but they felt they did. Because they spent more time on the topic they were more comfortable with it," says Conati. For these students, the simplified system provided enough stimuli to help them remember what they weren't able to in the pre-test. The more complex interface interfered with their learning, while it helped significantly those students who were newer to the topic. "Interface adaptability is becoming increasingly important with the growing use of computer applications throughout many different populations of users," states Conati.

EGEMS and socially intelligent agents

Since a computer cannot provide the level of adaptation required to enhance learning and performance by modelling cognitive states alone, there has been

continued on page 7

Haptics—Designing Tactile Interfaces

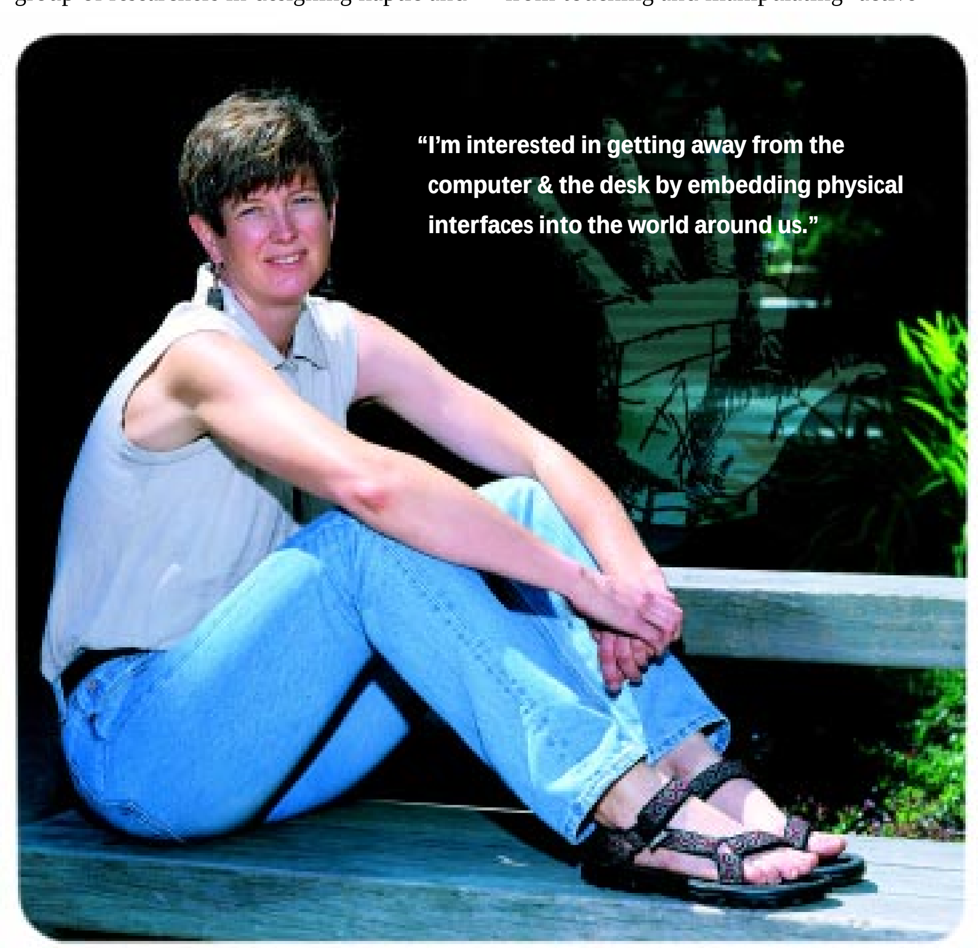
Karon MacLean uses haptic feedback to make human-computer interactions more comfortable, informative, powerful—and more pleasant.

As our activities are increasingly mediated by technology, human–computer interaction is becoming an inherent part of daily life. And if we consider how much time we now spend in front of a keyboard, and the problems caused by continually using and positioning our bodies in a certain way, we can begin to understand the focus of Karon MacLean's research.

"I like to consider the way things feel and the way we use energy in a physical sense, not just an electronic sense," says MacLean, a new member of CICSR and the Computer Science department. "And I want it to be more of a two-way flow."

Upon completing her PhD at MIT, MacLean went to Interval Research Corporation in Palo Alto, CA, where she led a group of researchers in designing haptic and multisensory user interfaces. "Interval was a wonderful experience because I was working with a very eclectic group of artists, musicians and sociologists. It really changed my views of what was possible, and desirable, in terms of interfaces."

However, after four years in the hypercharged, stock-obsessed environment of Silicon Valley, she was ready to return to academia. Why UBC? "Canadian universities have a healthy, supportive attitude that is better for cooperation and collaboration," says MacLean. "I like the department and the people—and, my fiancé is here."



Haptic feedback

Haptic feedback, or tactile and force feedback, refers to the sensations users get from touching and manipulating "active" interfaces—devices that use motors or actuators. The touchable interfaces MacLean designs are physical, embedded in objects or the environment around us, and target real applications. Combined with a visual display, haptics technology is used in virtual environments, or to train people for tasks that require hand-eye coordination.

Prototype haptic-feedback systems exist for surgeons, scientists, fighter pilots, astronauts, and crane operators. MacLean feels that these devices also have a place in our everyday world, with the potential to change the way we control home environment systems, view streaming media or drive our cars.

Active haptic feedback is an expensive feature, and not all interfaces need it. It adds the most value in "handle" type tasks where the user maintains continual manual control, as in steering a vehicle or drawing a picture. MacLean's belief in more cost- and energy-efficient technology has led to the creation of a new, integrated class of tools that combine these actuated handles with the "button" types of tasks used in selecting tools or triggering events.

One example is a drawing system that allows the user to choose between a physical brush, chalk or pencil that has been electronically tagged. The user then plugs the tool into a device that recognizes its physical properties and transmits the appropriate sensation of drawing or painting as the digital image is displayed. MacLean has recently been working with Immersion Corporation in San José, CA, to develop inexpensive, high-quality embedded devices.

Working with parasitic power

An avid environmentalist, MacLean is also concerned with the amount of energy technology consumes and the environmental impact of batteries. She came up with the concept of a parasitic haptic display that collects its power from the user.

continued on page 7

Pioneering Aspect-Oriented Programming

Gregor Kiczales is exploring new programming language constructs to facilitate the design and implementation of complex software systems.

Gregor Kiczales likes to swim against the tide, and in the world of computer software engineering, the sea is always turbulent. A former principal scientist with Xerox PARC (Palo Alto Research Centre), Kiczales left the sun of Silicon Valley for the rainforest of Vancouver to assume the NSERC-Xerox Canada-Sierra Systems Industrial Research Chair in Software Design at UBC. Why this reverse migratory path?

"UBC has a strong Computer Science Department, and I really wanted the chance to teach and work with students again. Also, my wife is from here," he says. In addition to the research chair, Kiczales says that a healthy five-year research stipend was an added incentive.

Beyond object-oriented programming

Kiczales' approach to software engineering research is practical in nature, and he enjoys and learns from the feedback real users provide. This sometimes puts him at odds with more theoretical researchers; but, as he says,"My goal is to come up with language constructs that real-world programmers want to use."

Previously, Kiczales worked extensively with object-oriented programming. Rather than dealing with programming and data as separate entities, where a program performs an action on a collection of data—a relationship often compared to the function of verbs and nouns in a sentence—object-oriented programming considers how the two are interrelated and then groups data, variables and function into a hierarchy of "objects." However, the hierarchical structure of object-oriented programming makes it difficult to deal with systemic concerns that crosscut different classes of objects.

"The problem with object-oriented programming is that as systems get large, more and more concerns arise that cannot be placed in just one point in the hierarchy. Programmers cope with this problem by duplicating code in several places."

Cutting across object hierarchy

Kiczales' approach, and his solution, seems simple. If a paradigm doesn't work, change it. If object-oriented programming can't crosscut system functionality—a problem that results in tangled code and instability—come up with something that can. At Xerox PARC, Kiczales developed Aspect J, a revolutionary language framework based on aspect-oriented programming (AOP) that allows programmers to cut across the object hierarchy. "When you write code in Aspect J, the language not only helps someone else coming in to understand it, but it also helps you to know every place where it applies."

"The data structure alone, or the program alone can't do any real work. What's right about object-oriented programming is that it breaks the program down to perform like many tiny computers all doing discrete tasks."

In addition to making programs more reliable, aspect-oriented programming addresses concerns such as error checking, resource sharing, processor optimization, monitoring and logging, and debugging support. AOP could also facilitate program upgrades and product line engineering.

Together with Xerox Canada, Kiczales and his students also intend to work on process control. They will research what happens when you write embedded control code for chemical processes, such as those used in toner manufacturing. The code appears to have some of the properties that aspect-oriented programming deals with much better than previous programming paradigms.

Kiczales notes that Aspect J was developed to be compatible with Java, so compromises were needed to achieve that goal. "If you were able to start with a clean slate, I think a useful academic project would be to see if we could develop something much more powerful," he says. "My work with CICSR and UBC will allow me to explore what AOP means in practice and to make better AOP languages."

Gregor Kiczales can be reached at gregor@cs.ubc.ca and (604) 822-4806.

Modelling Turbulent Flows to Understand Combustion

Kendal Bushe wants to help mechanical engineers build better, cleaner machines.

Combustion of hydrocarbons is still the most common source of energy on earth. It powers most of our machines and is critical to many engineering applications. And in almost all practical applications of combustion, the flow in which it takes place is turbulent. CICSR researcher Kendal Bushe is developing numerical simulations to study the complex relationship between turbulence and combustion.

"In order to design an engine, whether for a car, a jet, a generator, or even a large turbine for generating electricity directly, we need to understand combustion," says Bushe. Since turbulent fluid flow is an intrinsic aspect of combustion, subtle changes in the geometry of an engine can result in an enormous change in ultimate performance.

Until recently, automotive manufacturers would have several engineers come up with 50 to 100 designs and then build and test each one, notes Bushe. Over the past ten years, advances in computing technology, modelling and rapid prototyping have reduced the product design process from seven years to 18 months. However, the design process still requires many prototypes to test computer simulations. "I would like to provide simulations that can be trusted to give the right answer, to ultimately reduce the number of prototypes and shorten the design process," says Bushe.

Large eddy simulation

Most combustion processes, including those in diesel engines, gas turbines, and industrial furnaces, occur in a non-premixed mode. In these reactions, a plume of fuel spews into a chamber, or the air outside, and has to mix with oxygen before it can burn. "Unlike premixed combustion in spark-plug engines, the focus here is on the mixing, not the propagation mechanism," says Bushe. Before coming to joining UBC's Mechanical Engineering department he worked at the Center for Turbulence Research in Stanford on a combustion modelling method called Conditional Moment Closure that works particularly well for non-premixed flames, his special area of expertise.

At Stanford, Bushe also worked on large eddy simulations. "Turbulence is characterized by eddying motions, or swirling vortices that have a vast range of scales," he notes. Turbulence is also a three-dimensional phenomenon, so to model these large eddies, such as weather flows or jet streams, requires millions of data points for velocity, density, temperature, and composition—in each direction. He recently received an ASI Fellowship to continue his work on large eddy simulation.

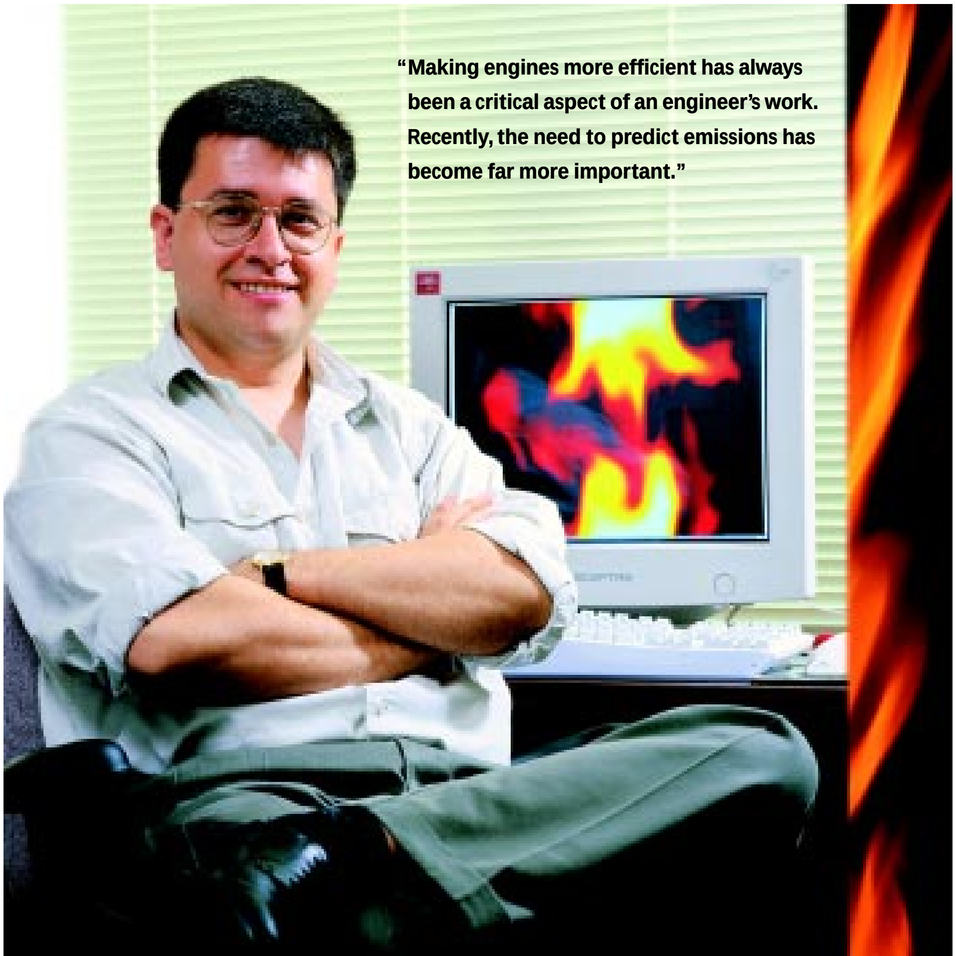
Predicting pollution emissions

"There is an enormous challenge right now to make predictions about carbon monoxide, nitric oxides and unburned hydrocarbons," says Bushe. "Also, the ability to predict soot, or smoke, is very limited."

As part of his work with CICSR, Bushe is working with Westport Innovations in Vancouver to do just that. The company is developing high-pressure direct injection technology that uses natural gas in diesel engines. Recently, the US Environmental Protection Agency proposed a new law to cut emissions of nitric oxides, particulate matter and sulphur oxides from diesel engines by ten times their current levels by 2007. Westport has one of the few technologies that can get close to those targets.

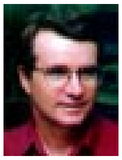
In exchange for his simulation and modelling expertise, Westport has provided considerable financial, in-kind and research support. "They are an amazing company, with great people," says Bushe. "I am trying to build a bridge between physicists and chemists who are using advanced simulation techniques, and the real-world engineers at companies like Westport."

Kendal Bushe can be reached at wkb@mech.ubc.ca and (604) 822-3398.

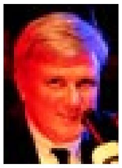


"Making engines more efficient has always been a critical aspect of an engineer's work. Recently, the need to predict emissions has become far more important."

CICSR Passing Notes



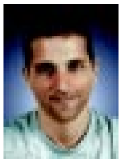
David Poole (CS) has been selected as a Fellow of the American Association for Artificial Intelligence. AAAI selects only 5 to 10 new fellows each year, and we are proud to have a CICSR member receive such prestigious recognition.



Nick Jaeger (ECE) and NXTPhase Corporation received the 2000 BC ASI Technology Partnership Award for their collaborative work on optical high-voltage sensors. This year ASI broke with tradition of only giving an award to the industry partner by recognizing Jaeger's contribution. He developed the key technology used in NxtPhase's Optical Voltage Transformer (see *Focus* Spring 2000).

In our last issue of *The CICSR News*, we reported that the Society for Canadian Women in Science and Technology (SWIST) launched a study to evaluate the participation of women in science and technology in BC between 1991 and 1996. In BC, women comprise only 14.4% of the high-tech work force. We hope that the recent number of women appointed to new IT faculty positions at UBC will help to reverse this trend.

Charles Laszlo



Murray Goldberg

Charles Laszlo (ECE), in his capacity as chairman of Assistive Listening Device Systems Inc., has won a 2000 National IWAY (Information Highway) Award for Adaptive Technologies. He also received the 1999 Meritorious Achievement Award from the Association of Professional Engineers and Geoscientists, and the 1999 Science Council Award.

Murray Goldberg (CS) won the IWAY Application of Technology award as president of WebCT Canada.

Yusuf Altintas (ME) reports two successful events on automation and machining. From May 1-5, 2000, the Manufacturing Automation Laboratory (MAL) gave a course on CutPro, the advanced machining software package developed by Yusuf Altintas's research group. The course was attended by nine engineers from the US, Holland, Germany, and Canada. From June 28-30, 1999, MAL hosted the 3rd IMS-SIMON Project Board and Technical Board Meeting. IMS-SIMON is a research consortium dealing with sensor-fused machining process monitoring and control. Thirty engineers and researchers from around the world attended the meeting to present their research.

In Spring 2000, **Clarence de Silva** (ME) received the IEEE Third Millennium Medal and the IEEE Canada Outstanding Engineering Educator Award.

CICSR welcome two new members this fall: **Tim Menzies**, who comes from NASA/West Virginia University, and **Rob Rohling** from ALI Technologies Inc., Vancouver. More about them in the next issue of *Focus*.

Conati: continued from page 3

increasing interest in the complex task of modelling emotional states. Researchers have been attempting to determine emotional reactions by measuring skin temperature, perspiration, heart rate, or facial expression with wearable devices. Conati is working on software tools that can be used alone or in tandem with physical apparatus to monitor and model emotional as well as cognitive response in order to improve the adaptivity of intelligent systems.

Since her arrival at UBC, she has been working on various projects for EGEMS (Electronic Games for Education in Math and Science). In Avalanche, one of EGEMS prototype games for collaborative learning, four players assume the roles of leading citizens in a mountain resort town and work together on a set of mathematical puzzles to try to prevent avalanches. Conati aims to develop socially intelligent agents, in the form of characters the students interact with onscreen, to help them find their way around the game, and to facilitate constructive learning, reflection and collaboration while preserving the high level of motivation and engagement the game generates.

"By providing adaptive support based on the user's cognitive and emotional states, these agents can help trigger learning behaviour—and they can also make sure that the fun is not impeding the learning."

Cristina Conati can be reached at conati@cs.ubc.ca and (604) 822-4632.

MacLean: continued from page 4

She and Prof. Li Shu, a colleague at the University of Toronto who specializes in design for remanufacturing, gave a group of UT undergraduate engineering students the task of making devices that collected enough power to charge an AA battery in one hour without the user changing activity or expending more energy. MacLean was amazed at the ingenuity of their devices—which included kitchen drawers and a dance floor—and their 100 percent success rate.

Her vision of home and work environments embedded with physical, environmentally friendly interfaces is perhaps closer as a result. "This is a new idea for me, and it presents a lot of challenges, but it is exactly the right thing to be working on in a university setting."

Karon MacLean can be reached at karon@kmaclean.com.

2000-2001

CICSR Distinguished Lecture Series

CICSR is hosting its 12th annual Distinguished Lecture Series, bringing in academic & industrial leaders in the forefront of their fields.

Lectures are free and start at 4:00 in room 208 of the CICSR/CS building, 2366 Main Mall, UBC.

Michael Lipsett

Brian Williams

Mary Vernon

Peter Shor

Hugo De Man

DATE	SPEAKERS
September 28, 2000	**Michael Lipsett**, Syncrude Canada Ltd., AB Intelligent Industrial Automation: Matching Research Programs to Technology Development Needs
October 26, 2000	**Brian Williams**, MIT Space Systems and Artificial Intelligence Laboratories, MA Model-based Programming of Robotic Space Explorers
November 30, 2000	**Mary Vernon**, University of Wisconsin, WI Scalable Streaming Media Servers
February 22, 2001	**Peter Shor**, AT&T, NJ Quantum Computing
March 29, 2001	**Hugo De Man**, Katholieke Universiteit Leuven, Belgium Rethinking engineering research and education for post-pc systems-on-a-chip

CICSR Centre for Integrated Computer Systems Research www.cicsr.ubc.ca

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 and Computer Engineering, and Mechanical Engineering. Currently, there are more than 80 CICSR faculty members who direct over 350 graduate students and collaborate with dozens of industrial firms in areas such as robotics, artificial intelligence, communications, VLSI design, multimedia, and industrial automation.

Return Address:

CICSR, University of British Columbia
289-2366 Main Mall, Vancouver, BC, V6T 1Z4
CANADA

Writer: Mari-Lou Rowley, Pro-Textual Communications

Design: William Knight, wilyum creative

Photos: Janis Franklin, Biomedical Communications

Office: University of British Columbia
289-2366 Main Mall
Vancouver, BC, Canada, V6T 1Z4

Tel: (604) 822-6894 **Fax:** (604) 822-9013

E-mail: cicsrinfo@cicsr.ubc.ca

Contact: Linda Sewell, Publications Coordinator, CICSR Office