INSTITUTE FOR COMPUTING, INFORMATION AND COGNITIVE SYSTEMS •I•C•I•C•S•

ICICS FOCUS

THE UNIVERSITY OF BRITISH COLUMBIA

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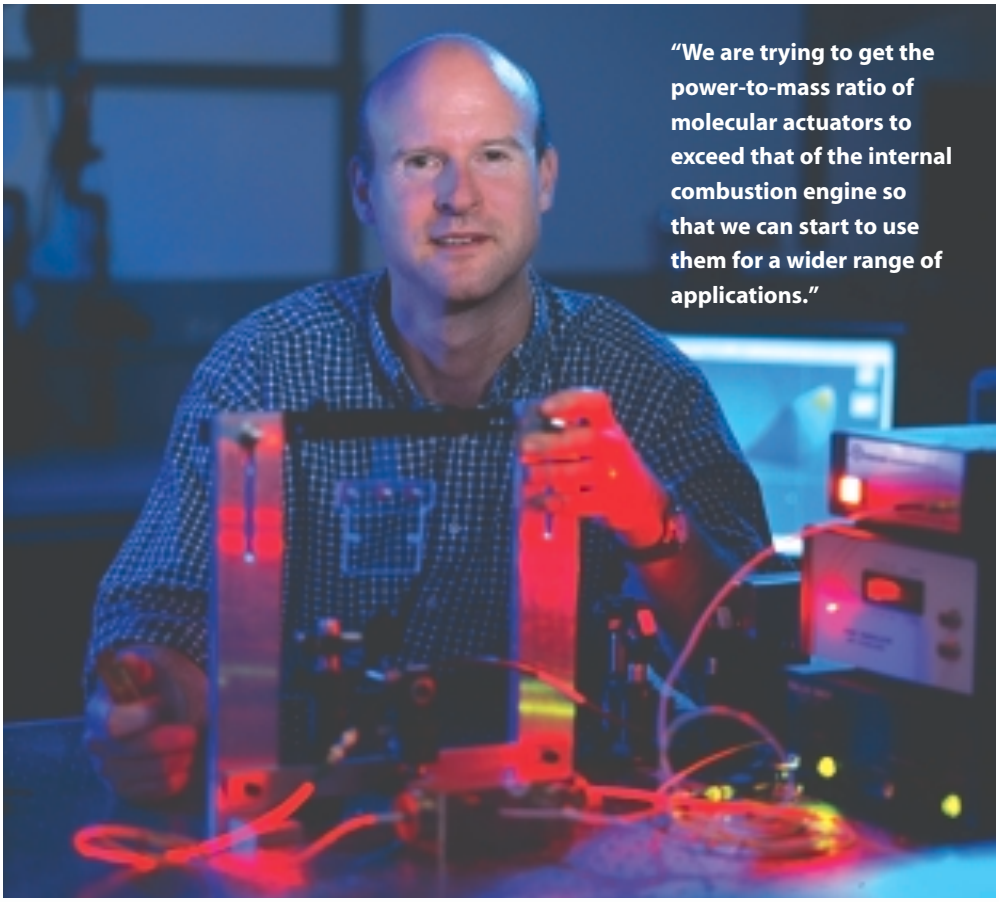
Flexing Molecular Muscle

- Conducting Polymers
- Molecular Actuators
- Super Capacitors

John Madden works at the intersection of materials/electrical engineering, mechanical engineering, physics, chemistry, and biology to design and fabricate novel materials at the molecular level.



"We are trying to get the power-to-mass ratio of molecular actuators to exceed that of the internal combustion engine so that we can start to use them for a wider range of applications."

Imagine flying robots. Submarines with fins for propellers. Artificial muscle that generates 100 times more force and three times the power to mass as human muscle. Imagine being able to construct entire devices with one class of material and a single fabrication process. This might sound like something out of a sci-fi novel or Steven Spielberg movie, but researchers are closer to turning fantasy into fact than we think.

New ICICS member John Madden's lab is working to design and hone the properties of conducting polymers, a unique class of synthesized molecules that mimic muscle by changing shape in response to changes in oxidation state. The material alternately swells and contracts at the molecular level—somewhat like an accordion—as you add or remove electric charge. The result is powerful molecular actuators that should lead to breakthroughs in robotics, artificial organs, and nanosystem fabrication. "There is still room for improvement," notes Madden. Challenges include increasing the cycle life and the power output.

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ICICS

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ICICS Director's Corner

In this issue of Focus, we introduce you to eight new ICICS members, whose research spans disciplines in the Faculties of Science, Applied Science and Arts.

Robert Hall (Mining Engineering) is working to improve the performance and reliability of mining equipment. Alan Kingstone (Psychology) is studying how the brain integrates sensory input and how this affects attention and memory. His collaboration with other members is helping to develop human-centered technologies.

Frank Lam (Forestry) engineers stronger and safer wood products for the global market. John Madden (ECE) designs and synthesizes conducting polymers to fabricate new materials at the molecular level. Walter Mérida (ME) works at the forefront of fuel cell and hydrogen technology to develop sustainable energy systems. In the field of human-computer interaction, Joanna McGrenere (CS) works to develop more adaptable and efficient interfaces that accommodate individual differences.

In order to keep up with traffic on wireless networks, Robert Schober (ECE) designs algorithms and systems that can handle the demand for higher data rates and increased reliability. Ruben Zamar (Statistics) incorporates robust data processing methods into software to help the non-statistician model mixed-quality data.

Finally, Computer Science Head, Robert Woodham shares his insights on progress, change and the future of computer science after eight years as head and 25 years in the discipline. The department has seen much growth and progress under his leadership. This year he will be taking a well-deserved sabbatical—and I will miss him.

Rabab Ward, ICICS Director

***Madden:* Continued from page 1**

Machines that Flap and Fly

Traditional actuator technologies are combustion engines or electric motors, which are most powerful when operating at high rotation rates. "This is not very convenient if you are trying to make an artificial limb, a robot or nanoscale device," says Madden. Or if you are trying to fabricate a fish. He is working with the US Office of Naval Research to review novel actuator technology and develop biomimetic propulsion mechanisms where "either the propellers flap like a bird's wing or the whole structure flaps like a fish."

With funding from IRIS and NSERC, Madden and new ICICS member Joseph Yan (ECE) are developing artificial flying insects. "We are trying to insert our muscle technology into Joseph's micro-robots to create a dragonfly." Although, like much basic research, the work may seem rather esoteric, it has potentially important applications in surveillance and the detection of toxic or hazardous materials.

Fuel Cells and Super Capacitors

The material also has applications in micro-pumps, detectors and batteries. Certain battery technologies require air vents that open and close at low cost and low voltage. "One advantage of conducting polymers are that they are driven by low voltages," notes Madden. Another is that unlike our own muscles, but like the muscles in a clam, they have a catch mechanism that enables them to lock shut, maintaining force without expending energy.

Another promising application is fuel cell technology, since conducting polymers have five orders of magnitude higher capacitance than traditional capacitors. (A device the size of a business card exhibits a capacitance of more than one Farad.) This is important for fuel-cell and battery-driven electric cars, where the energy is regenerated during braking. These "super capacitors" would provide a more efficient and less cumbersome alternative to current battery technology.

Along with ICICS member Dave Pulfrey (ECE), Madden is working on novel nanotube transistors, which have many interesting properties. "Unlike a conventional wire, a charge carrier appears to propagate down a carbon nanotube without loss of energy," says Madden. His work seems to be bringing alchemist's dreams and sci-fi fantasies closer to reality.

John Madden can be contacted at 604.827.5306 or jmadden@ece.ubc.ca

Adopting Adaptive Interfaces

Discovering what humans really need from technology is a goal of ICICS—and new member Joanna McGrenere's work in human-computer interaction (HCI).

- **Participatory Design**
- **Deep Customizability**
- **Adaptive / Adaptable Interfaces**

The marketing of software products has resulted in a frustrating phenomenon. Software "bloat"—where products are so feature-laden that their benefits are outweighed by their complexity and demands on computing resources—was the initial focus of McGrenere's research. She discovered that, given the option of jettisoning unused features, a significant number of people still want to be able to explore all features, even if they seldom use them.

Understanding the User

Two main approaches are used to accommodate individual differences among users. In adaptive interfaces, the system modifies the design based on what it knows about the user. In adaptable designs, the user makes the modifications. "Different kinds of users are more willing to have adaptive interfaces than others," says McGrenere. She is studying how people experience software in order to design systems where users have more control over adaptability. McGrenere has been working with ICICS member Kellogg Booth (CS), and Gale Moore and Ron Baecker, both from U of Toronto, to research Microsoft Word and Office products. To accommodate the need for both simplicity and functionality, they have designed a multiple interface where users can toggle between a simple, personalized version, and the full-featured interface. The group has received funding from IBM's Centre for Advanced Studies and in-kind support from Microsoft.

Designing Assistive Technology

In the Aphasia Project, McGrenere is collaborating with Peter Graf (Psychology), Barbara Purves (School of Audiology and Speech Sciences) at UBC, and Maria Klawe (Engineering and Applied Science, Princeton). The group is exploring a number of HCI issues relating to cognitive disabilities in language and speech. "The overall goal is to improve the quality of life and independence for people suffering from aphasia," says McGrenere. The work intensifies the task of designing technology to accommodate individual difference. Over 100,000 people in Canada and 1 million in the United States suffer from aphasia, usually as a result of stroke, brain tumour, or brain injury. Although most aphasic individuals retain their ability to recognize image-based representations, there is a huge discrepancy in the level of speech and language impairment. For example, some people cannot read at all, others cannot write, and others have lost the ability to speak. Some can speak quite clearly but have lost certain nouns and verbs. "As a result of this huge variability, the challenge is to achieve deep customizability in the technology we design," says McGrenere.

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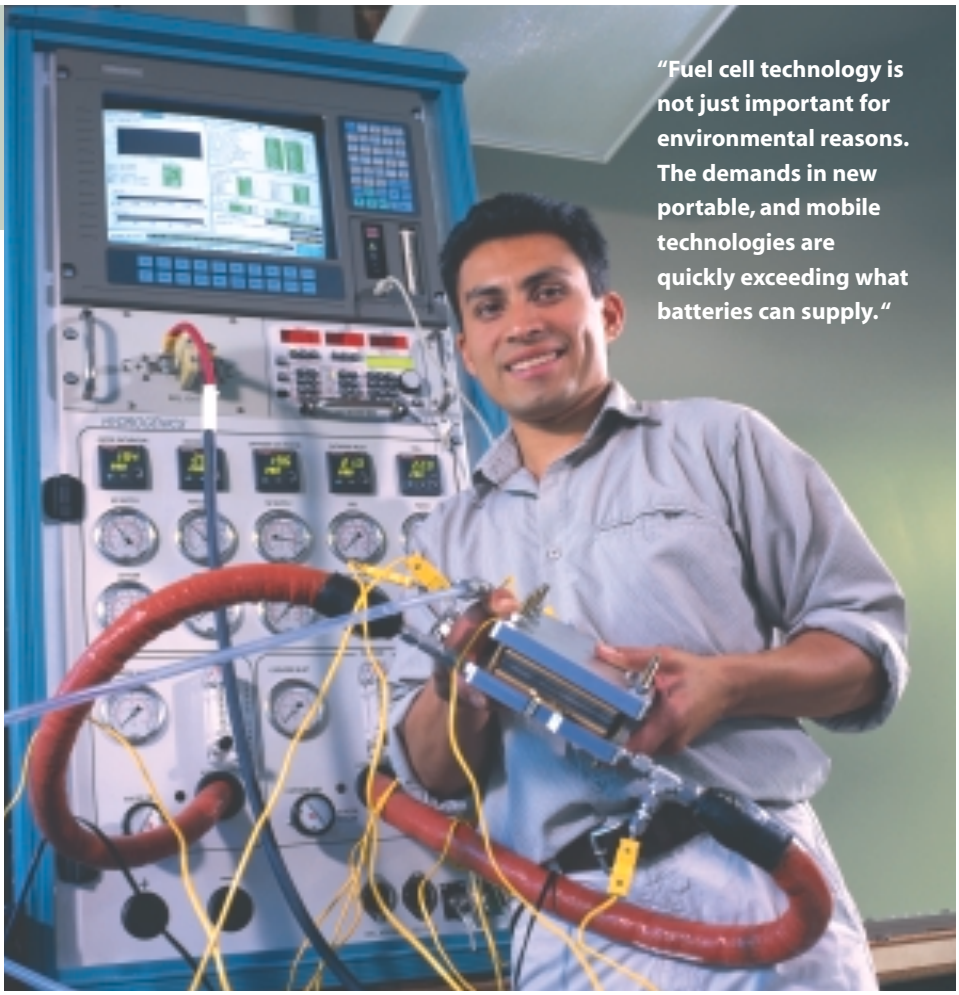
"Our goal is to make easy-to-understand, adaptable interfaces in order to simplify use while retaining more complex functionality."

Energy Systems Come Clean

Walter Mérida works at the forefront of developing sustainable energy systems, fuel cell technology and alternative fuels.

- **Clean Energy**
- **Electrochemical Energy Conversion**
- **Hydrogen Technology**



"Fuel cell technology is not just important for environmental reasons. The demands in new portable, and mobile technologies are quickly exceeding what batteries can supply."

When we think of clean or alternative energy, we often think of wind, solar, or tidal power. "All these sources produce electricity, but the problem is that right now we cannot store this energy efficiently," says new ICICS member Walter Mérida. In other words, if you convert energy from these sources, you have to use it right away.

Electrochemical energy conversion can provide a crucial link between all available energy sources and the services that society demands—without combustion, and with very low emissions. Mérida notes that in order to make a dent in climate change, we need to have clean energy for transportation systems. Hydrogen and fuel cell systems will be able to penetrate this energy sector, traditionally the domain of fossil fuels.

Hydrogen Systems—Elegant Symmetry

Electrochemical energy conversion is a cyclic process where hydrogen combines with an oxidant to produce electricity that is channelled through an external circuit. The only by-product is heat and water. Conversely, water electrolysis can convert water and electricity to hydrogen.

Although initial fuel cell technology for cars will rely on external sources of hydrogen, Mérida has already designed an integrated system for the production of ultra-pure water and electrolytic hydrogen to produce electrical power in stationary and mobile applications. He marvels at the symmetry and beauty of the process. "In current combustion models we do things by brute force; we set explosions and harness work from them. This is a much more controlled and elegant way of doing things."

Another advantage of fuel cells is that they can be easily miniaturized. "We see a lot of potential applications in medical and portable technologies, and many things that we just can't predict yet." From 1996 to 2002, before joining UBC, Mérida collaborated with key partners in industry, including Ballard Power Systems, General Hydrogen, and Greenlight Power Technologies, now a division of Hydrogenics Corporation.

Mérida is a member of the newly created Clean Energy Research Centre (CERC) at UBC (a $9 million investment including funds from CFI and BCKDF). The Centre received an additional $540,000 infrastructure funding from Western Economic Diversification Canada to conduct leading-edge research into fuel cell systems and hydrogen technologies. Along with ICICS members Kendal Bushe (ME) and Ian Frigaard (ME), Mérida is also a collaborator in the NRC's Institute for Fuel Cell Innovation.

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Getting Our Attention

- **Cross-modal Research**
- **Significance-based Attention**
- **Attention and Cognitive Neuroscience**

Associate Professor of Cognitive Systems in the Department of Psychology, Alan Kingstone's research supports ICICS's mission to develop human-centered technology.

How does the human brain integrate touch, sight and sound? How does it experience shape perception? And what role does attention play in memory? These are some of the questions that Alan Kingstone, ICICS member and director of the Brain and Attention Research Lab, is attempting to answer.

"We are working to understand perceptual experience and how people use the information in the world around them," says Kingstone. He and his 20-member lab are pioneering a paradigm shift in the way cognitive systems are studied and understood. Take the standard hearing test as an example. A person is in a sound-proof environment, without any background noise, distraction or other external stimuli to process. Since all of her attention is focused on listening, deficits that occur in the real world might well be missed in such an artificial setting "If you are not verifying what people are doing in a real world experience, then you end up studying things that only tell you how we perform in an impoverished environment," says Kingstone.

Traditional research in attention and perception suggests that fundamental, or primitive, features such as light, sound, colour, and shape, have no meaning in themselves. It is only through the brain's bricolage that meaning is made. In contrast, Kingstone and postdoctoral research fellow Daniel Smilek believe that even the most primitive stimulus-feature has meaning, and that the function of human attention is to serve in the selection of meaningful information from the environment that is important to both the individual and the task at hand.

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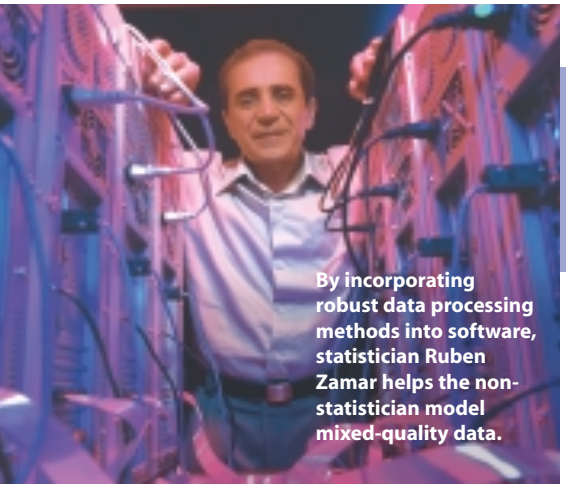
Corralling Data "Outlaws"

- **Robust Inference**
- **Data Mining**
- **High-Dimensional Data**
- **Outliers**

"If these outliers are errors, we don't want to be influenced by them. And if they are important nuggets of information we would like to flag them for further study."



By incorporating robust data processing methods into software, statistician Ruben Zamar helps the non-statistician model mixed-quality data.

In today's exploding data terrain, quality is everything. An errant data cluster—or even a stray data point—can play havoc with classical methods of analysis. Pinpointing stray data that appears to be "alone in the range" is one of the ICICS member Ruben Zamar's specialities. His work in robust inference differs from traditional statistics in that it uses the majority of the data, rather than all of it, to construct a robust model. This procedure also helps identify data "outlaws" or outliers, which can distort the model.

Zamar has been working with CS colleagues Raymond Ng and Edward Knorr on identifying outliers in high-dimensional data, where numerous measurements are performed on each subject in a dataset. One proposed application of their work is scouting for star NHL players, by analyzing speed, goals scored, assists, ice time, penalties, and physical strength. "We would also want to identify players who are unusual in some way," says Zamar. This work also has potential applications in the stock market, education, the insurance industry, and video surveillance.

A growing focus of Zamar's work is interactive data mining. He and fellow ICICS members Raymond Ng, Laks Lakshmanan and Alan Wagner received funding for their work from the Mathematics of Information Technology and Complex Systems (MITACS). "Our goal is to make data mining a cooperative process between human and computer," says Zamar. The group is also part of the iCAPTURE Centre, a partnership between St. Paul's Hospital, the Vancouver Hospital and Health Sciences Centre and UBC to study heart, lung and blood vessel diseases. The Centre received $17 million from CFI and the BC Knowledge Development Fund, and IBM is supplying the IT infrastructure. Initial funding for Zamar's group came from McDonald Research Laboratory and Insightful Corporation. iCAPTURE will be able to link genomic information and environmental influences with patient data. "Making this information available to researchers and improving data mining techniques is important for improving health outcomes."

Ruben Zamar can be contacted at 604.822.3167 or ruben@stat.ubc.ca

Advances in Mining Engineering

- **Crushing Optimization**
- **Integration of Information Systems**
- **Remote Mining Applications**

ICICS member Robert Hall works on the performance, reliability and design of mining equipment to improve productivity and efficiency in an extremely competitive business.

In recent years, the mining industry has adopted new technology in order to remain competitive. The trend toward larger, more complex equipment has resulted in significant challenges in the areas of maintenance and reliability. Production monitoring systems and machine embedded monitoring and control technologies have produced a plethora of underutilized data. "The integration of information technology has not been used to address the fundamental design of these machines," says mechanical engineer Robert Hall. Development and integration of mine equipment information systems is one aspect of his work.

Teleremote mining operations is another. As head of the Mine Automation and Environmental Simulation Lab, part of UBC's CERM3 group of labs that will be shared with ICICS, Hall is working with ICICS colleague Peter Lawrence (ECE) on teleremote testing and software development. The goal of the lab is to examine remote mining applications and to integrate individual processes to reduce mining and processing cycle times.

Hall and ICICS member Farrokh Sassani (ME) are working with EJC Tamrock Loaders in Burlington on load-haul-dump (LHD) machines, the primary production equipment in underground mining. Traditional LHD designs have used diesel to power the hydraulic system.

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Innovations in Composite Lumber

- **Structural Wood Composites**
- **Wood Fibre Geometry**
- **Seismic Loading**

Upon entering the Forest Sciences Centre at UBC, the first thing you notice is the high, vaulted ceiling supported by what appears to be massive sawn beams of solid timber. They are actually some of the Centre's finest technology at work. The beams are structural composite lumber made from oriented strands of wood —each up to 2.4 meters long. Several elements are involved in monitoring and modelling the orientation and other characteristics of strands, as well as the resin and heat used in the manufacturing process. ICICS member Frank Lam, Dave Barrett (Wood Science) and ICICS colleague Peter Lawrence (ECE) use random field theory to try to understand and define how the arbitrariness of these characteristics relates to the properties of wood in order to improve their structure and performance.

Recent ICICS member and Associate Professor in Wood Sciences, Frank Lam engineers wood products that are stronger, safer and more competitive in the global market.

"Engineering composite wood products requires knowledge of how different production parameters influence properties such as strength and stiffness."

Developing engineered systems that resist seismic loading is another aspect of Lam's research. He, Ricardo Foschi and Helmut Prion from Civil Engineering demonstrated that using engineered wood panels in shear walls dramatically increases strength, ductility, and stiffness. As part of a collaboration between UBC and UC San Diego, they are working to develop analytical tools and design procedures for earthquake-resistant timber frame construction.

Lam's research is also spearheading changes in design codes to support market development for Canadian wood products overseas, with the current focus on the emerging Chinese market. Since the Cultural Revolution, most housing in China has been built out of concrete. In an effort led by the Council of Forest Industries and Forintek, Lam is helping to reintroduce timber engineering to Chinese universities and improve the Chinese building code. "People there prefer Western wood frame construction, so the potential market is enormous. We are helping to bridge the knowledge gap."

Frank Lam can be contacted at 604.822.6526 or franklam@interchange.ubc.ca

Bob Woodham's Computer Science Vision

Poised to step down after eight years as Head of Computer Science at UBC, Bob Woodham reflects on progress, change and the future of the discipline.

- **Culture of Collaboration**
- **Computational Intelligence**
- **Cross-disciplinary Research**

"Computers are inevitably interacting with people, and we are working to facilitate that interaction; that is a key component of what we are about."

The field of computer science has evolved exponentially in the 25 years since Bob Woodham joined UBC's Computer Science Department. Since assuming the position of head in 1995, he attributes the department's success to its ability to attract talented new researchers, to its core group of exceptional faculty, and to a culture of collaboration. "We are an outstanding department because of our ability to put together teams, and to cross traditional barriers both within the discipline and across to other disciplines in a way that gives us a distinct competitive advantage."

Woodham credits the Faculty of Science and the University for recognizing the value of this collaborative vision within the reward structure of appointment, promotion, tenure, and discretionary salary increases. He credits ICICS in providing the vision, infrastructure, and leverage that allows researchers to attract competitive research funding. Woodham notes that ICICS, the Networks of Centres of Excellence (NCE) Program, and the Canada Foundation for Innovation (CFI) have also facilitated the development of the experimental aspect of computer science, an area where Canada lags behind other nations. "People tend to see computer science as being either theoretical or applied and miss the experimental side, which requires significant infrastructure and equipment and cannot rely on corporate funding."

Maintaining a Broad Vision

One of the challenges that Woodham has faced has been to ensure that the curriculum keeps up with advances in the field. Another has been to help instil a broad view of the discipline as it is increasingly linked with other fields. He notes that when he joined the department, many graduate students were admitted to CS with undergrad degrees in other disciplines. Today, the CS graduate student who does not have a CS undergrad degree is an exception.

"Many of our incoming graduate students have a much narrower view of what computer science is than what is characteristic of our department." Woodham wants to dispel the notion of the solitary code cruncher. The department has new undergraduate degree programs that he hopes will encourage students to combine CS with other disciplines. "Employers increasingly tell us that our graduates will need to be able to work in cross-disciplinary teams," he says.

From Vision to Motion

Woodham's research in AI and computer vision has established him as a pioneer in physics-based vision systems.

Continued on back page

Optimizing Wireless Communications

As traffic on wireless networks increases, Robert Schober is developing new algorithms and systems to keep up with the demand for higher data rates and increased reliability.

"While my interest is in the math and algorithms behind wireless communications systems, my hope is that others will be able to do something useful with my work."

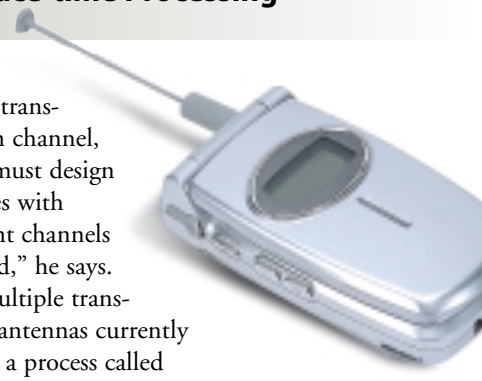
- **Multi-user Detection**
- **Interference Suppression**
- **Space-time Processing**

By 2004, an estimated one billion people worldwide will be using some form of wireless device. From cell phones, mobile radios and hand held devices, to global positioning systems and satellite-based security systems—the demand is taxing the available bandwidths of the radio spectrum. With new applications emerging all the time, the challenge is to design systems with high data rates, high quality of service, and high spectral efficiency.

New ICICS member Robert Schober is Canada Research Chair in Wireless Communications and he recently received the prestigious Heinz Maier-Leibnitz Award from the German Science Foundation. Schober's focus is the mathematics of wireless systems software, and he is keen to collaborate with local industry in order to encourage technology transfer and commercialization. He is designing systems that make optimal use of the frequency bandwidth, ward off interference from other systems, and have low power consumption.

Space-Time Processing and Coding

One aspect of Schober's work, space-time processing, involves designing algorithms for multiple transmitter antennas in order to get the best performance possible with affordable system complexity. "The design strategy depends on the transmission channel, so we must design schemes with different channels in mind," he says.



Multiple transmitter antennas currently require a process called channel estimation before information can be transmitted. Schober is developing algorithms that eliminate the need for channel estimation. "Since everything comes at a price, the disadvantage is that this method is less power efficient," he says. "This is where my work really starts."

Improving CDMA Receivers for 3-G Wireless

Code Division Multiple Access (CDMA) is employed in third generation wireless networks. It enables several users to be on the same channel simultaneously within a cellular system—efficiently and inexpensively. Another goal of Schober's work is to decrease the complexity of receivers while maintaining performance. For example, linear multi-user receivers detect desired users while curbing interference from other users. "I am trying to come up with the best receiver structures for CDMA systems for any given complexity," Schober says.

Given the delicate balance of high data rates, power efficiency, optimal performance, increased use, and finite frequency bandwidth, he has his task cut out for him.

Robert Schober can be reached at 604.822.3515 or rschober@ece.ubc.ca

McGrenere: ***Continued from page 3***

With funding from ICICS, UBC Faculty of Science, NSERC, and with pocket PCs provided by Hewlett Packard, the group is developing assistive technology for people with aphasia. A fundamental—and challenging—aspect of the group's approach has been the participation of the aphasic users in the design process. MSc student Karyn Moffatt, one of the collaborators, has already developed a prototype electronic daily calendar that incorporates images and sound as well as text in an interface that runs on top of the Microsoft Outlook engine.

"The HCI community has an important role to play in developing technology for users with cognitive disabilities."

Joanna McGrenere can be contacted at 604.827.5201 or joanna@cs.ubc.ca

Mérida: ***Continued from page 4***

Improving Design and Reducing Failure

His recent work has focused on the architecture and testing of Proton Exchange Membrane (PEM) fuel cells. His non-planar prototype used three-dimensional designs to achieve up to three times the power density of previous two-dimensional (planar) designs. The new architecture can be fabricated in a continuous, automated process compatible with mass production schemes

Water management is a major challenge of PEM fuel cells. The polymer membranes require humidity, but water in the microstructure can hinder the transport of reactants. Previous voltage tests could not distinguish whether a failure was due to membrane dehydration or microstructural flooding. Mérida has developed a diagnostic technique that distinguishes between the two problems.

"The fuel cell industry has become very competitive, but in the area of testing and failure diagnosis Canada still has a clear lead."

Walter Mérida can be reached at 604.822.2914 or wmerida@mech.ubc.ca

Kingstone: ***Continued from page 5***

"If there is meaning even in a simple sound or flash of light—and we believe there is—then traditional research has only been gaining a glimpse of what the attention system is designed to do and what it is capable of doing."

Kingstone and Smilek are working with ICICS colleagues Karon MacLean (CS) and Kees van den Doel (CS) on multi-modal influences on attention and performance. Kingstone's funding partners include the Michael Smith Foundation for Health Research, NSERC and Nissan Motor Co. He has also received a prestigious Human Frontiers Research Grant and funding from the Human Early Learning Partnership, a network of researchers from BC's four major universities, directed by Dr. Clyde Hertzman. "We are actually suggesting a whole new conceptualization of human attention," says Kingstone "What we are saying is that meaning matters—always, in all situations."

Alan Kingstone can be contacted at 604.822.9230 or alan.kingstone@ubc.ca

Hall: ***Continued from page 6***

With regulations on air quality and engine emissions becoming increasingly stringent, the team is studying how fuel consumption, power cycle requirements, hydraulic systems, and digging practices (aggressive/moderate) of different operators influence power draw. This research will lead to better monitoring and control strategies to produce more efficient diesel/electic systems, new tools for design, and training tools so operators can use machines more effectively.

Hall is also working with Highland Valley Copper on wear analysis and real-time monitoring of crushers to investigate the relationship between particle size, liner wear, throughput, and reliability. "In all of these projects we are working to improve data management and analysis in order to get useful information for day-to-day operations and to design better equipment."

Robert Hall can be reached at 604.822.0066 or rah@mining.ubc.ca

"Within both the underground and open pit environment, the application of autonomous and semiautonomous technologies is not fully understood."

Passing Notes:

ICICS Welcomes New ECE Head

Vijay Bhargava, newly appointed head of Electrical and Computer Engineering, assumed his position on July 1, 2003. Vijay came to UBC from the University of Victoria, where he was professor of ECE from 1984 to 2003 and served as founding graduate advisor of the department. His research interests include digital communications, error-correcting codes, and future systems and technologies. He has received numerous awards for his work, including the IEEE Centennial Medal, the A.F. Bulgin Premium of IEE, U.K., and the John B. Stirling Award of the EIC. He has also provided consulting services to industry and government. Welcome Dr. Bhargava.

Mabo Ito retires from ECE

Acting head of Electrical and Computer Engineering from July 2002 to June 2003, and member of the department since 1973, **Mabo Ito** is retiring from the department. A pioneer in the areas of real-time systems, computer communications, and image and signal processing, the applications of Mabo's work were diverse, from improved performance of real-time multimedia delivery over IP networks, to the detection of landmines in battlefield conditions. We wish him a peaceful and happy retirement.

Klawe and Pippenger move to Princeton

Computer Science professor and dean of the Faculty of Science from fall 1998 to fall 2003, **Maria Klawe** will be leaving the department to take up her new position as dean of the School of Engineering and Applied Science at Princeton. Maria was head of Computer Science from February 1988 to February 1995. She also served as vice-president, Student and Academic Services and held the NSERC Chair for Women in Science and Engineering. Her work on E-GEMS: Electronic Games for Education in Math and Science, has been developed into a successful commercial product.

Nick Pippenger, CS professor and expert in complexity theory and computational topology, will be moving to Princeton with his wife Maria, where he will be professor in the Department of Computer Science. At UBC, he held a Canada Research Chair in Computer Science.

Both Maria and Nick will be greatly missed and we wish them all the best at Princeton.

New Building on Track

The new ICICS/CS building is on schedule for completion for the fall 2004 term. The site is ready and concrete is being poured. Stay tuned for more updates.

***Woodham:* Continued from page 7**

His work is critical to understanding the nature of intelligence in order to make intelligent machines. "The ability to perceive and interact directly with the world is key to intelligence," he says. His current research focus is motion, the area he plans to continue in when he steps down as head in December.

What has been the most startling development over his past 25 years in computer science? "Technological advances have made problems that one could have only speculated about, now something we can address," says Woodham. "Now we can deal with 30 frames per second video in real time, and that makes significant work in motion—and many other areas—technically feasible."

Bob Woodham can be contacted at 604.822.4368 or head@cs.ubc.ca

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UBC's Institute for Computing, Information and Cognitive Systems (ICICS) is an umbrella organization that promotes collaboration between researchers from the faculties of Applied Science, Arts, Commerce, Dentistry, Education, Forestry, Medicine, Pharmacy, and Science. ICICS supports the collaborative computer-oriented research of more than 125 faculty members and over 500 graduate students in these faculties. ICICS researchers attract approximately $15 million in annual grants and contracts. Their work will have a positive impact on us all in the future.

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

CANADA POSTES POST CANADA
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Writers: Mari-Louise Rowley, Pro-Textual Communications

Design: Jarret Kusick, Hitman Creative Media Inc.

Photos: Janis Franklin, UBC Media Group
Greg Morton, UBC Media Group

Editor: Gale Ross, Administrative Assistant

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

Tel: 604.822.6894

Fax: 604.822.9013

E-mail: info@icics.ubc.ca