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

ICICS FOCUS

THE UNIVERSITY OF BRITISH COLUMBIA

Studying How Infants Learn Language

New ICICS member Janet Werker's research with infants and toddlers sheds new light on language acquisition.

"I need this collaboration with ICICS...The ICICS group has the engineering experience I need," says Canada Research Chair Janet Werker.

The acquisition of language is a milestone in human development that remains, for the most part, a mystery. Is it an innate ability? Is it developmental? Is the brain hard-wired for language? Psychology professor Janet Werker is trying to solve these riddles, one baby at a time. The director of the Infant Studies Centre at UBC and her research group are looking at the properties of language that infants develop and the way these prepare a child for language.

By measuring the strength of sucking in newborn infants, and the length of looking in six-month old babies, Werker and colleague Rushen Shi discovered that neonates differentiate between lexical words (nouns, verbs) and grammatical words (articles, prepositions, other connective terms). By six months, babies show a distinct preference for lexical words.

Preference for Lexical Words

In a recent study, Werker and Shi found that immigrant babies whose families only spoke Cantonese or Mandarin showed an equally strong preference for English lexical words. "This shows that babies are using the surface forms of speech to 'bootstrap' into language," she says.

Infants are also able to make fine grammatical distinctions between different consonant sounds. To an English speaker, the French *p* and *b* both sound like a *b*. Conversely, French speakers hear English *b* and *p* both as *p*. Babies hear both. Werker, post-doc Tracey Burns and undergrad Karen McVie have found that at the ages of six to eight months, English and French babies can distinguish both *b* and *p* sounds, but by ten to twelve months they only distinguish those used in their language. Bilingual babies keep both, and the older they get, the stronger the evidence seems to be.

Werker is principle investigator (PI) of an international collaboration that has received funding from the Human Frontiers Science Program out of Geneva to study the behavioural and neural effects of exposing children to another language and culture in extreme situations, such as foreign adoption or refugee displacement.

The more Werker and her team learn about the development of language skills, the better able they are to identify children at risk

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ICICS
Director's Corner

The group of new researchers featured in this issue of Focus exemplifies the ICICS mandate of interdisciplinary research and collaboration, and points the way for exciting new developments in computer applications.

Janet Werker's research in how infants learn language has significance for other types of learning. Laks Lakshmanan's focus in database systems is to help manage, integrate and mine data. Lee Iverson designs systems that integrate data from various sources and facilitate on-line collaboration. Matthew Choptuik uses super computers to model and study extreme gravitational events. Nando de Frietas is taking machine learning to exciting new levels. Peter Danielson is an expert in applied ethics, a crucial new field. Michiel van de Panne uses human biomechanics to perfect the motor skills of robots and animated characters.

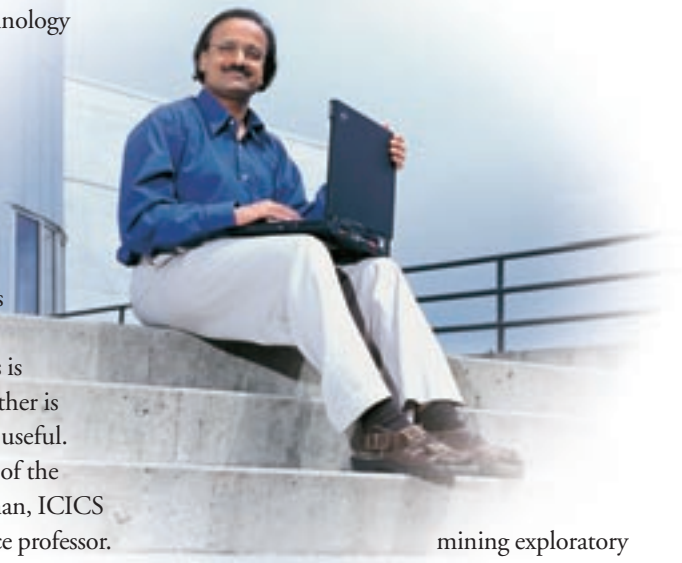
We also have an update on the new ICICS building addition and facilities. Excitement is starting to build as we look forward to the new addition's construction.

I also bid farewell to Jim Varah, one of the founders of ICICS, who has retired from the department of Computer Science after 31 years. Jim was also a founder of ICICS' predecessor, CICSR, and served as its first director from1986 to 1996, overlapping a three-year stint as head of Computer Science. Jim's vision of a truly collaborative research institute continues to bear fruit, as this issue of Focus proudly illustrates. We will miss Jim, but his legacy with ICICS lives on.

Rabab Ward, ICICS Director

Discovering the "Schema" of Things

A world expert in database systems, Laks Lakshmanan is working to organize, integrate and tame a spreading jungle of data.



Advances in information technology have posed some interesting paradoxes. For example, as the sources and amount of data increase, and more information is available online, it becomes more difficult to find what we are looking for. How data is ordered, or its "schema," varies from source to source. But this is only part of the problem. Another is defining, and finding, what is useful.

"Usefulness lies in the eyes of the beholder," says Laks Lakshmanan, ICICS member and Computer Science professor. Integrating structured data in relational databases with semi-structured and unstructured data from the web is one challenge of his work. Another is designing query languages that enable information extraction and analysis based on the user's unique focus.

Querying XML Data

The standard for exchanging information over the Internet is XML, a self-descriptive syntax that works very well for semi-structured data. Along with colleagues at the University of Michigan and AT&T Research, Lakshmanan has developed the first bulk algebra for querying XML data. The group is now building a prototype system for processing XQuery, which is set to become the standard query language for XML. A pioneer in developing query optimisation techniques for XML, Lakshmanan's work on WebLog, a language for querying the Web, is an oft-cited classic.

He is also developing tools to query data from non-database sources, such as spreadsheets, which currently use rather primitive query operations.

Locating sources of data is one thing. Finding the golden nuggets of information among the labyrinthine tunnels is another. Lakshmanan's vision for efficient data mining involves three key aspects. First, make the mining exploratory so that the user can influence the focus of the search. Second, treat the patterns that are discovered on par with the data itself. Third, give the user the ability to do further pattern discovery against raw data—and not crash the computer.

With Raymond Ng, also of Computer Science, and a colleague from AT&T Research, Lakshmanan has developed a Three Worlds (3W) Algebra to integrate these three levels of data analysis in a seamless fashion. They will also be collaborating with a group from the University of Antwerp on this research. Carson Leung, a Ph.D. student, collaborates with Lakshamanan and Ng on online algorithms for data mining.

Lakshmanan credits ICICS, the Mathematics of Information Technology and Complex Systems (MITACS), and the Institute for Robotics and Intelligent Systems (IRIS), for providing collaborative and financial support for his work.

While mathematics is the heart of Lakshamanan's work, music provides food for his soul. "In my spare time I enjoy Carnatic music, which is South Indian classical music and one of the most beautiful formal systems," he says.

Contact Laks Lakshamanan at laks@cs.ubc.ca or (604) 822-3153.

Real-Time, Online Collaboration

Lee Iverson designs systems that enable computers to do more organizing, interpreting—and thinking for humans.

Anyone who has worked on a multi-authored document knows the difficulty in keeping track of changes and revisions. Usually, we end up with information, corrections and various iterations dispersed among emails, computer files, hard copy, and faxes. "We need systems that can record, share and interpret our own knowledge and reasoning in a way that can be easily used by both human and computer collaborators," says ECE Assistant Professor Lee Iverson.

Iverson recently came to UBC from SRI International Artificial Intelligence Centre, in Menio Park, California where he worked in computer vision, computer graphics, software engineering and design, web-based infrastructure, and geographical information and visualization systems.

Supporting Synchronous Communication

How can we best manage and utilize the plethora of data that we collect over the course of a day, week, or year? And what if that data is constantly changing? What if we want to collaborate on-line? Lee Iverson is working on systems to answer these questions and to better support synchronous (on-line) communication. He designed NODAL, a web-based shared-file system and document database for a computer-based collaboration.

"We want to be able to integrate information from emails, meeting transcripts and even phone conversations," says Iverson. "There is a lot of implicit knowledge here and often the credit for an idea gets lost." He believes that if we can catalogue and integrate all sources of knowledge, then we will have the ability to re-examine decisions in a much more dispassionate, egalitarian manner.

One way companies protect their customer base is by preventing the data that their users produce from being referenced or used in competitive products. He says that the most important information is trapped in a hodgepodge of proprietary databases that fail to get information to the user. Iverson dreams of building a universal distributed database infrastructure "where anybody in the world, at any point in time could make a simple request and find exactly what they want."

"We want to be able to integrate information from e-mails, meeting transcripts and even phone conversations."

Systems That Think

In addition to his research in distributed computing, forensic data discovery, and knowledge management, Iverson is interested in developing intelligent agents.

As a writer, I imagine a system that can record conversations, identify multiple speakers, capture intonation and accent, and automatically transcribe the conversation or meeting. "To do accurate transcription you must have some understanding of vocabulary and context," says Iverson. "If the system doing the transcription is aware of your goals, then its job becomes very different." Given current speech recognition standards, there is a lot of room for innovation.

Iverson is glad to be back in Canada, and in a research environment that can support his vision of a universal system of information sharing, retrieval and management that is available to everyone, not just the targeted few.

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New ICICS Members Tackle Black Hole Collisions, Thinking Machines and Technological Ethics

Eclectic—essential. The work of our growing cohort of ICICS researchers crosses boundaries, traverses shifting terrains, and even probes galaxies to shed light on the changing worlds of technology and human experience. **Matthew Choptuik** (Physics and Astronomy)**, Peter Danielson** (Centre for Applied Ethics) and **Nando de Freitas** (Computer Science) join over 100 others in ICICS's 30 research groups to share new ideas and foster interdisciplinary research collaborations.

photos: NASA, H. Ford (JHU), G. Illingworth (UCSC/LO), M. Clampin (STScI), G. Hartig (STScI), the ACS Science Team and ESA

Black hole collisions and other extreme sports

Physicist Matthew Choptuik has been making waves by simulating cosmic collisions and predicting infinitesimally small black holes.

There are only a handful of physicists in the world today who specialize in the obscure field of numerical relativity. Matthew Choptuik is one of them. His research in the "extreme sports" events of cosmology—supernovae, colliding black holes and neutron stars—has been garnering a lot of attention, and accolades. Choptuik was a recipient of the Rutherford Memorial Medal from the Royal Society of Canada in 2001, and recently, he was awarded the CIAR Young Explorers Prize.

The Choptuik Effect

Not many people can take on Stephen Hawking. Choptuik has, and won, although the bet was wagered by colleagues at Caltech. He predicted that in certain models of gravitational collapse, it is possible to form black holes that are arbitrarily small. "As a corollary, the calculations implied the theoretical possibility of a 'naked singularity'—an event in space-time visible to the outside world, where gravitational forces become infinite," says Choptuik. When his calculations were repeated by researchers at Cambridge, Hawking was convinced.

Choptuik's simulations of cosmic explosions include gravitational waves, as yet undetected forces analogous to electromagnetic radiation that physicists believe are emitted after extreme gravitational events. Modelling these "ripples in space-time" may help experimental physicists to detect them.

Simulating phenomena such as black hole formation and collision requires considerable mathematical acumen and enormous computational power. Choptuik is part of a group of researchers in BC and Alberta who recently received $12 million in CFI funding for a large-scale computing infrastructure for solar system studies, and numerically intensive research in particular. He is developing computational techniques to make strong-gravity calculations more efficient. Choptuik notes that he tends to take a different approach than his counterparts. His group uses as much computing power as they can get their hands on, while their individual calculations are relatively modest by numerical relativity standards. "You are not going to get any information out of a single calculation, no matter how complex."

Contact Matthew Choptuik at 604-822-2412 or choptuik@physics.ubc.ca.

"Since my work involves high-performance computation it will really benefit from a tighter coupling with computer scientists."

Resolving ethical dilemmas in high-technology

Ethical theorist Peter Danielson uses sociological models to resolve high-tech ethical issues.

In the wake of rapid technological development, Peter Danielson poses a much-needed question: who benefits—and at whose expense? As the Mary and Maurice Young Professor of Applied Ethics, he uses his background in philosophy and evolutionary game theory to help other researchers and students study and resolve important ethical issues. For example, members of UBC's Centre for Applied Ethics are working with clinicians from various hospitals to study issues in bioethics. Another member is advising a fast food chain on more humane methods of animal slaughter. "We are working with people who are making on-the-ground decisions," he says.

Game Theory and Ethical Robots

All ethical decisions involve compromise or cooperation, often pitting individual goals or needs against collective good—a common theme in game theory. For example, why are half of the cars on the road now SUVs? People feel safer in an SUV than a compact car, although the vehicles are less stable and consume much more fuel. Individual need versus collective good. The Kyoto Accord falls into the same dilemma.

"On some level it doesn't matter what the agents are, whether it is a person buying a car, a government making energy policy, or robots sharing bandwidth," says Danielson, author of Artificial Morality, Virtuous Robots for Virtual Games. "People working with multi-agent systems are dealing with the same problems."

He cites Alan Mackworth's soccer-playing robots (Focus 13.1) as the perfect example. The robots cooperate to score goals and outwit the opposing team—at the expense of individual glory. A classic mistake in almost all game models is to think of situations as merely competitive.

"It doesn't matter whether you are talking about a hive of bees, a robot soccer team, a business group, or an army platoon," he says. "Even a competitive unit requires altruism and cooperation." Danielson's observation hits upon a cornerstone of ICICS—and evolutionary theory. The fittest also know when to collaborate.

Contact Peter Danielson at pad@ethics.ubc.ca or 604-822-0537.

"Technology changes almost everything. It raises critical ethical issues that we have to sort out; we can't simply apply some predefined answer."

Teaching the machine to learn

Computer scientist Nando de Freitas designs algorithms, programs and machines that learn.

When we first learn language, we construct abstractions that enable us to match words to the things we see, hear and smell. Once we are able to assign words to perceptions, we learn to manipulate them with syntax and grammar. The process is similar with all intelligent learning agents. Machine learning involves deriving abstractions of the real world through observation, making decisions under uncertainty, predicting future events, classifying massive quantities of data quickly, and finding patterns in data.

"Abstractions of what we encounter on the web enable us to design search engines that allow people to query with words, images—and even sound—at the same time."

Percieving Part of Reality

"We can't observe the entire content of the Web any more than we can simultaneously observe the entire content of a room," says computer scientist Nando de Freitas. "We only perceive part of reality, and yet we make decisions based on that." Learning machines are designed to come up with optimal decisions in the absence of complete information.

A practical example of this is a program that can detect abnormalities in medical tests and industrial processes. De Freitas is designing agents that can scan large amounts of data (including images, musical scores and text) and also learn from these data collections. Hospitals, news agencies and museums are examples of businesses that have huge collections of visual, textual and audio data on the Web and could benefit from this research. De Freitas notes that learning agents also provide more realistic and interactive characters in computer games, so they have a wide array of applications.

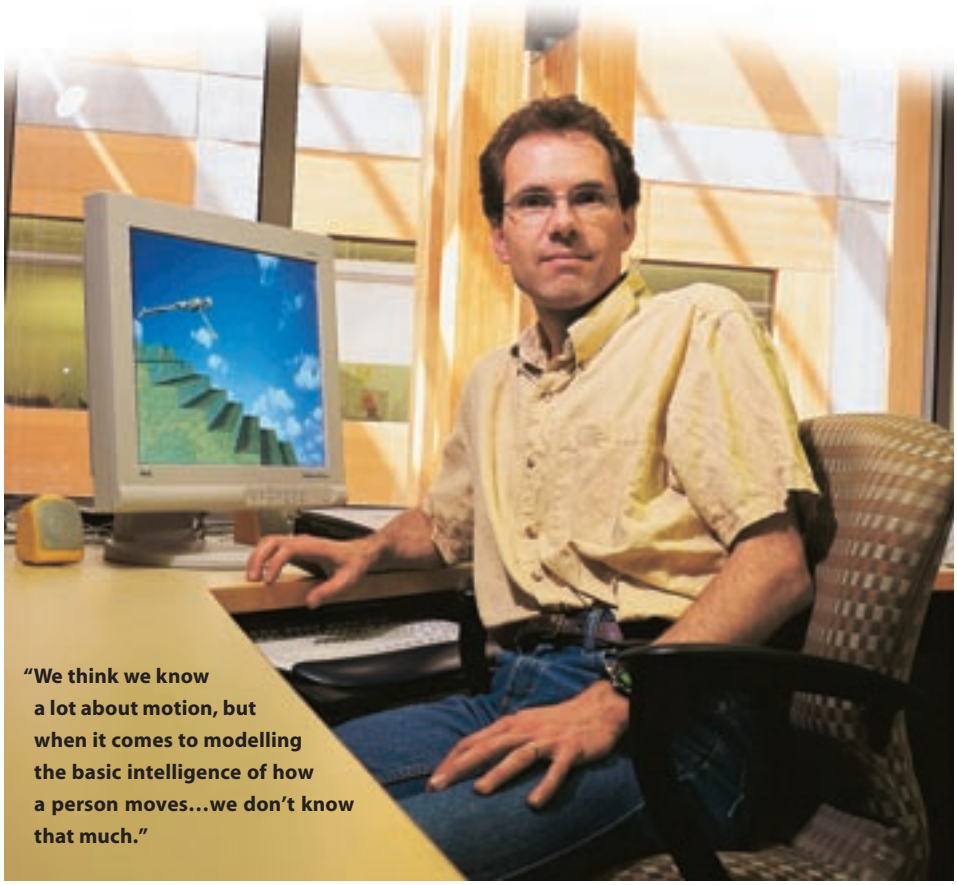
De Freitas and his colleagues from UC Berkeley were the first researchers to do image-text translation—work that has revolutionized the field of object recognition and that earned his group the European Computer Vision Conference Prize for the best paper on cognitive vision. At ICICS, he is collaborating with Alan Mackworth on a robotics project, and with Ron Rensink on research funded by Nissan (see Focus 13.1).

"Eventually, we will have robots that will be able to look at things and tell us what they are seeing," says de Freitas. "My real work is coming up with the probabilistic models and the algorithms to learn these models."

Contact Nando de Freitas at nando@cs.ubc.ca or 604-822-6770.

Moving Beyond Simulated Realism

Michiel van de Panne's goal is to create characters and robots that possess a broad repertoire of life-like motor skills.



"We think we know a lot about motion, but when it comes to modelling the basic intelligence of how a person moves…we don't know that much."

Chuck Jones, a master of classical animation, excelled at depicting a wide range of movement and emotion. The wild gestures of Yosemite Sam, for example, create a vivid impression of character and life, though they are hardly realistic. While recent advances in computer graphics have raised the bar of realism in animation, creating compelling motion still remains a challenge for computer animators. Michiel van de Panne, an associate professor of Computer Science and an ICICS member, wants to meet that challenge by taking animated motion to the next level: real-time physics-based movement.

Robust, Autonomous Skills

Van de Panne's goal is to give characters and robots robust, autonomous physical skills whose movements obey Newton's Laws. This means that internal muscular forces are modelled in interaction with the external forces of gravity and resistance—and the result is realistic motion. The task is complex and requires an interdisciplinary skill set including biomechanics, robotics, machine learning, control theory, and computer animation.

"We think we know a lot about motion, but when it comes to modelling the basic intelligence of how a person moves or plans their motions, we don't know that much," says van de Panne, who holds a Canada Research Chair in Graphics and Multimedia.

To simplify the job, van de Panne uses the divide-and-conquer technique. In the Digital Stuntman project, a physics-based computer model of human movement that he created with UCLA's Petros Faloutsos, van de Panne separated out the control of human movement into unique sets of motion controllers.

These controllers model individual skills such as balancing, walking, or the reaction of breaking a fall, for example. When the Stuntman (which is actually a skeleton) falls down a flight of stairs, his body falls as dictated by physics and the stuntman's embedded reactions, rather than being directly keyframed by an animator.

Physics-Based Acrobatics

Van de Panne's work in physics-based motion can also be seen in a shareware game he developed called Ski Stunt Simulator. The game allows a player to explore and perform physics-based acrobatic ski stunts on a variety of terrain and jumps.

What's different about Ski Stunt is that the skier's movements are new and original every time you play. In a conventional game, movements are typically pre-set. A player manipulates a character from a stock library of motions, but cannot invent new ones.

In Ski Stunt's direct interactivity, van de Panne sees potential uses as a teaching tool in human kinetics and biomechanics, and as a point of departure for building sports prototyping tools for freestyle skiers and divers. You can download Ski Stunt Simulator, or play an online demo at www.motionplayground.com.

Another of van de Panne's interests is in developing more effective interfaces for animation and modelling programs.

"Current 3D modelling tools are complex and have steep learning curves. I want to build interfaces that make them more accessible. I only need the time to do it all!"

Reach Michiel van de Panne at van@cs.ubc.ca or at 604-822-8737

·I·C·I·C·S· Passing Notes

ECE's **Nick Jaeger** and the research team at NxtPhase Corporation have been chosen for the R&D 100 Award. Their Nxtphase Voltage and Current Transducer (NXVCT) will be recognized at the 40th Annual R&D 100 Awards Banquet to be held in Chicago, IL, on October 16th. This award is given to the creators of the 100 most technologically significant new products introduced into the marketplace over the preceding year.

Wolfgang Heidrich and **Ron Rensink** (both of CS) have been awarded the Peter Wall Early Career Scholarships. These were awarded on the basis of the quality and degree of interdisciplinarity in their research. Some of Ron Rensink's research is part of a year-long exhibit on vision happening at the Exploratorium in San Francisco.


Wolfgang Heidrich


Ron Rensink

Clarence de Silva (ME) has been given the Lifetime Achievement Award by the World Automation Congress "…in recognition of his outstanding contributions to the field of Intelligent Automations and Its Practical Applications." Also, earlier this year, de Silva was appointed the Editor-in-Chief of the International Journal of Control and Intelligent Systems.

Nando de Freitas (CS) and three other researchers won the Best Paper on Cognitive Computer Vision at ECCV 2002, a conference held by the European Research Network for Cognitive Computer Vision Systems. Their paper, "Object Recognition as Machine Translation: Learning a Lexicon for a Fixed Image Vocabulary," represents research the trio has conducted into object recognition and classification for use in advanced database searches.

ICICIS Building Addition: Another step closer

The planned ICICS building addition is another step closer to reality. Functional planning-deciding on space, usage and technical requirements-was completed this past spring, and the design document is now being prepared by project architects Hotson Bakker and Bregman Hamann. ICICS researchers worked closely with them to complete the functional planning phase.

The ICICS addition (as shown in this article's backdrop) will be built on the old vivarium site behind the current CS/ICICS building. The present atrium will be extended into the new ICICS addition and will be instrumented as a large, interactive, virtual, inter-media environment (go to www.icics.ubc.ca/projects/building to see a colour computer rendering of the proposed joined atrium space).

As well, a quadrangle is planned for the space between the present CS/ICICS building, the ICICS addition and the planned CS addition, which will occupy a site at the corner of Engineering Road and Agronomy Road. Tender documents for the ICICS addition are expected to be ready in January 2003. The projected occupancy date for the new building is August 2004.


ICICS founders KD Srivastava and Jim Varah are pictured here with current director Rabab Ward. Absent is co-founder Martha Salcudean.

James Varah retires

Former director of CICSR (now ICICS) James (Jim) Varah has retired after 31 years with the department of Computer Science. He headed the CS department from 1984 to 1987 and served as CICSR's first director from 1986 until 1996. Since that time, he has been active at all levels, sitting on nearly 30 committees.

Jim completed his Bachelor of Science at UBC before moving to Stanford for his Master's and PhD degrees. After teaching for two years at CalTech, he returned to UBC in 1971, joining the Computer Science's faculty of four.

Early on, Jim identified the collaborative research imperative. His perserverance came to fruition with the establishment of CICSR. Jim has been an inspiring role model for both students and faculty. He's put an enduring stamp on the CS department, and his contribution continues to flourish under the new banner of ICICS.

Werker, *continued from page 1*

of developing language and learning disorders—and of designing methods of early intervention.

Werker's state-of-the-art lab, funded by CFI, includes four sound-attenuated testing rooms, a studio for creating audio-visual stimuli and analyzing infant behaviour, a conference room—and toys and a diaper change area. The lab also has an eye-tracker that Werker has yet to get up and running. "I need this collaboration with ICICS," she says. "Five years ago there were questions that I was avoiding asking because I didn't think the work was possible in Canada. The ICICS group has the engineering experience I need to help solve these problems."

Contact Janet Werker at jwerker@cortex.psych.ubc.ca or 604-822-6741.

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January 30, 2003
Prospects for Growth in BC's Technology Sector
George Hunter BC Technology Industries Association

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Uncertainty, Utility, and Interaction
Eric Horvitz Microsoft

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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 120 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.

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