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

ICICS FOCUS

THE UNIVERSITY OF BRITISH COLUMBIA

From Solar Cells to System-on-a-Chip

IEEE Fellow David Pulfrey finds meaning in work that has a social impact.

David Pulfrey believes in a balanced lifestyle. He lists forming the first ECE cricket team alongside his year 2000 appointment as an Institute of Electrical and Electronics Engineers (IEEE) Fellow among the highlights of his long career at UBC. Since joining ECE in 1968, Pulfrey has enjoyed several incarnations in his field of semiconductor devices. An ICICS member, he currently works in the System-on-a-Chip group with other members such as Resve Saleh (see *Focus* Spring 2001 issue), specializing in physical problems associated with signal integrity in mixed-signal circuits.

Avid cyclist and IEEE Fellow David Pulfrey has been spotted in Stanley Park on his way to work—from his home on Dunbar Street, taking the long route.

Pioneering alternative energy systems

Starting as an "experimentalist" mainly in the area of solar cells, in 1979 Pulfrey wrote *Photovoltaic Power Generation*, one of the first books on solar cell systems, which ranged from the physics of devices to the socio-economic implications of their implementation in alternate energy-generating systems. This led to an invitation to teach a related course at the Institute of Engineering in Kathmandu, which he describes as the most rewarding teaching experience of his life. He taught engineers, planners and bankers in a country where the very real prospect exists for alternate energy systems to improve the lifestyle of inhabitants. This experience solidified his deep interest in teaching, and holistic view of his work.

Pulfrey's research focus evolved from solar cell devices to high-speed bipolar transistors, mainly for use in very fast digital systems. During a sabbatical in 1982 he worked for Plessey Research in England, where his orientation shifted from experimentalist to theorist/device modeller. His speciality moved from bipolar junction

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ICICS
Director's Corner

Building a new research institute is a demanding and rewarding challenge. My warm thanks to Anne Condon for her excellent work as Acting Director during my recent sabbatical and to everyone who has contributed to making ICICS a reality.

With the evolution of CICSR into ICICS, we have been busy with the exciting task of allocating $22 million in infrastructure funding. We have identified seven ICICS user clusters and appointed cluster leaders: Modelling Humans and Their Environment (Sidney Fels, ECE); Creating Human Experience and Multimodal Interfaces (Dinesh Pai, CS); Multi-Agent Systems (Clarence de Silva, ME); Global Information Systems (Mabo Ito, ECE); Computational Models Complexity, New Paradigms & Applications (Holger Hoos, CS); System-on-a-Chip Technologies (Andre Ivanov, ECE); Social & Behavioural Sciences (Ron Rensink, CS and Psychology).

This issue of Focus profiles senior and recent ICICS members. ECE faculty member David Pulfrey's career has spanned three decades — from photovoltaic power to mixed signal circuits. New CS faculty member Will Evans' work has applications in wireless devices and software visualization tools. Robert Rohling (ECE and ME) is working to improve 3D ultrasound and medical imaging techniques. Kris de Volder (CS) is using logic meta programming to bridge the gap between software design and writing code. And Antony Hodgson (ME) is studying the biomechanics of motor skills to help test and design medical robotics.

Rabab Ward, ICICS Director

ICICS name officially approved

Our new name, **ICICS** (the Institute for Computing, Information and Cognitive Systems) was officially approved at the November 26, 2000, meeting of the UBC Board of Governors. A final decision on the architects who will design the new building will have been made in late summer. The four short-listed firms are Architectura Planning Architecture Interiors Inc.; Chernoff Thompson Architects; The Colborne Architectural Group, Pacific Inc.; and Hotson Bakker/Bregman + Hamann Associated Architects.

Pulfrey, *continued from cover*

transistors in silicon to heterojunction bipolar transistors (HBTs) in other material systems, notably gallium arsenide, indium phosphide and gallium nitride.

Much of his work has been sponsored by Nortel and the creation of physical models for HBTs contributed to that company's development of the world's first very high-speed (10Gb/s) fibre optic telecommunication systems. He continues to do consulting work with Nortel.

Pulfrey's philosophy: "Keeping groups small and working collegially instead of managerially."

Working for positive change

Effecting change is an important component of Pulfrey's work. He notes, "The award from IEEE resulted from having an impact on the community, and the work with HBTs for Nortel is the same; also a couple of other devices have had documented impact by their inclusion in widely available software for programmable memories (EPROMs), and in portable power systems for artificial hearts."

Given this outlook, it is not surprising that his enthusiasm for teaching has remained high. His 1989 undergraduate text book, *An Introduction to Microelectronic Devices*, set the trend for using popular circuit simulators as a pedagogic tool to analyze devices. In 1990 he became the inaugural recipient of the UBC Killam Teaching Award for Engineering. He was the first professor enlisted by PMC-Sierra to give courses at their in-house university on the physics and technology of deep sub-micron systems in May of this year. He is a Distinguished Lecturer for the IEEE, and was a Distinguished Visiting Lecturer at the University of Western Australia earlier this year.

Pulfrey's philosophy? "Keeping groups small and working collegially instead of managerially" and "picking a useful problem to solve and not setting out to write 10 papers a year" has enabled him to maintain rigorous standards without tempting burnout. Along with riding a bike to work every day for the past 32 years, this approach has led to his combination of good health, community involvement and academic excellence.

David Pulfrey can be reached at pulfrey@ece.ubc.ca or (604) 822-3876.

Simon Yiu wins first Peter Cahoon Memorial Internship

Simon Yiu

Congratulations to **Simon Yiu** (ECE) who is the first winner of the **Peter Cahoon Memorial Internship**. The internship was created in memory of Peter, a long-time mentor to UBC students, by MAGIC (the Media and Graphics Interdisciplinary Centre) and CICSR, and provides partial support over the summer to students who are involved in an interdisciplinary research activity. It is also hoped that the internship will encourage further education at the graduate level. Simon is working with **Victor Leung** (ECE) on the potential application of remote monitoring and control of residential appliances and electronic devices using a Wireless Application Protocol (WAP) phone and X10 devices.

Understanding the Way We Move

Biomedical engineer Antony Hodgson's research in neuromotor skills has applications in medical robotics, rehabilitation, and surgical ergonomics.

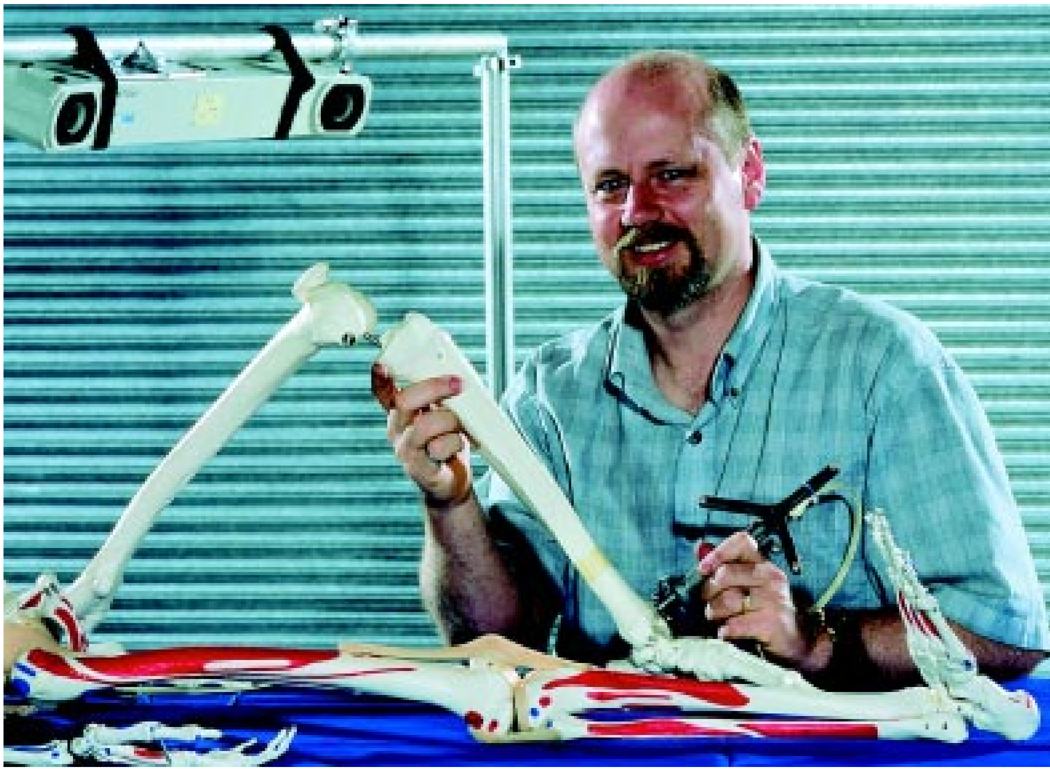
The human body in motion is a magnificent and complex system. Consider a dancer's effortless leap, a golfer's hole-in-one or a neurosurgeon's deftness with a scalpel. Even the tasks we perform every day require an intricate interchange between neurons and muscles. The complexity of human movement is what Antony Hodgson is working to decipher.

"The body isn't thinking about exactly where the arm is going," says Hodgson, ICICS member and director of UBC's Neuromotor Control Lab. We use information from all of our senses to tell us where our limbs are in space. And this information is used to refine our motor plans—whether executing an inside fastball or a pirouette.

Practice makes perfect

"A robot's sensors can tell you within a fraction of a millisecond where it is and how fast it is going, and its controller can rapidly change the amount of torque being applied," says Hodgson. In contrast, human actuators—or muscles—behave more like controllable springs than torque sources. The brain smoothly varies the muscles' equilibrium lengths depending on the task at hand. Sensors in the muscles send information back to the brain relatively slowly, so the brain is not involved in fast reflex responses. Rather, it plays more of a planning and supervisory role, issuing occasional corrections to the plan if needed. "The brain acts in a largely feed-forward way; it pre-plans the movement and then gets information back about how the movement went," says Hodgson. This means practice really does make perfect.

The nature of Hodgson's research demands collaboration with neuroscientists, kinesiologists, electrical and computer engineers, and computer scientists. He is currently working with Janice Eng at the GF Strong Rehab Centre to assess upper limb function following traumatic brain injury in order to establish more quantitative clinical assessment techniques for rehabilitation.



Dr. Hodgson demonstrates the use of an optoelectronic localizing probe to find the anatomic centre of the ankle during a mock-up of a computer-assisted knee replacement procedure. A current project in his lab aims to replace this anatomic digitization with a kinematic analysis of the ankle joint motion

"Current techniques are very subjective; if a patient transfers from one physician to another, the measurements of their performance may also change."

Hodgson is also working with Elizabeth Croft in Mechanical Engineering on air muscle-powered robots. Their goal is to build low-cost robotic devices with built-in compliance to mimic how humans handle objects. These could be useful in the home—for example to assist the elderly to perform tasks they find difficult to do.

Improving orthopaedic surgery

In collaboration with Bob McGraw and the Orthopaedics Dept. at UBC School of Medicine, and with funding from Johnson and Johnson, Hodgson is using robotic and computer technology to aid orthopaedic surgery. One project is a non-invasive alignment system to improve the accuracy and lifespan of knee implants.

Laparoscopic surgery—minimally invasive for the patient but a major challenge for the surgeon—is the area of Hodgson's research that involves the largest collaborative effort. He is working with Karon MacLean in Computer Science, Karim Qayumi, head of the Centre for Excellence in Surgical Education at Vancouver Hospital, laparoscopic surgeon Alex Nagy, and Lance Rucker, head of the Centre for Operative Simulation in the School of Dentistry. With funding from NSERC and the Society of American Gastrointestinal Endoscopic Surgeons (SAGES), they are working to improve the technology and training for this procedure. Hogson's involvement includes developing tools and protocols for making biomechanical and ergonomic assessments, assessing new

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In the Beginning is the Code

ICICS member Kris De Volder wants to bring the language of humans and computers closer together.

Software development is extremely complex—and, according to computer scientist Kris De Volder, one of the least predictable of industrial processes. "There is a notion that you can start from a general picture and then continue to refine it until you finally get something that works, but it's not that simple." The current approach to software design and maintenance is like trying to climb up a waterfall. When you start from the concept and work down to code, it is almost impossible to go back and make revisions. "That's why we have so much bad software and why there is so little code reuse," says De Volder. "In many cases it is simpler just to start from scratch."

Bridging the gap between human and computer, or programmer and compiler, may help solve this problem. "In the beginning we didn't have any programming languages, only binary code," says De Volder. Simple assembly languages were developed, followed by procedural languages, data abstraction, and then object and aspect-oriented programming. "By adding these layers of abstraction we can raise the language we use to instruct the computer to a higher level."

Logic meta programming

De Volder is using logic meta programming to navigate this gulf in software evolution. Logic programming involves writing programs based on logical inference, or rules of proof and implication. Most popular programming languages are imperative. A computer is given a set of procedural instructions: do A and then B followed by C. Logic programming is more declarative. "You never really instruct the computer in a direct way. Instead you give it different rules to infer truths, so it is a totally different flavour of programming."

Meta programming is writing programs about other programs. This is not as uncommon as one might think. For example, a compiler is a meta program that translates high-level programming language into a lower level language. But writing programs that write other programs is extremely complex. De Volder believes that using logic programming to do meta programming might provide the right kind of formalism to simplify the task.

TyRuBa

If we compare a programming language to a car, and a programmer to the driver, we can more easily understand De Volder's work. As drivers we typically don't build vehicles, we just drive them. Similarly, programmers don't usually develop programming languages—they use existing ones to write programs. And like cars, there are many different types, or models, of programming languages and not all work equally well for certain tasks. Typically, the vehicle we buy must traverse variable terrain. And the options we choose for our car are only available on certain models and must be installed by the manufacturer.

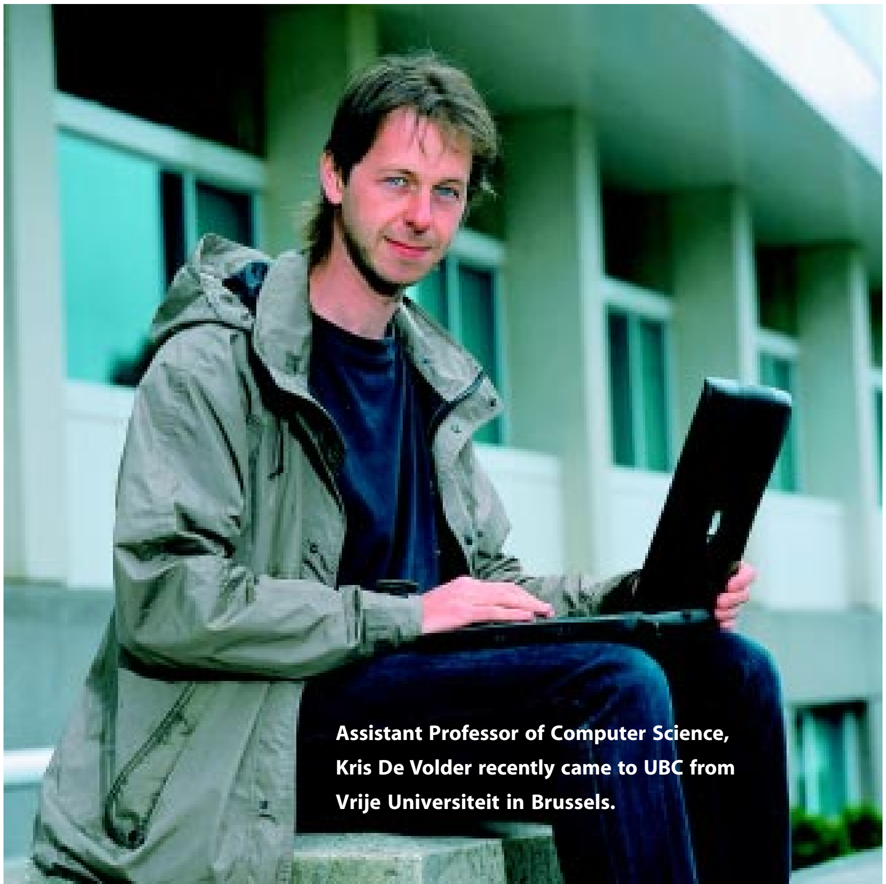
"What meta programming does is promote the programmer/driver to mechanic," says De Volder. "So the programmer can design, build and install new options for the program."

> **"What meta programming does is promote the programmer/driver to mechanic."**

Logic meta programming could also be a mechanism to help develop generic programs that are reusable in many contexts.

De Volder developed TyRuBa (for Type Rule Base), a prototype logic meta programming system to generate Java code. TyRuBa allows the programmer to add new options to the programming language more easily. For example, when programs operate on a shared resource—such as a printer or memory—to do several tasks simultaneously, synchronization is critical. Unsynchronized behaviour results in bugs, crashes and data anomalies. This is particularly true for programs that work on networks or the Internet. "Incidentally, Java, considered "the" language of the Internet, provides very poor support for synchronization," says De Volder. He uses TyRuBa to add an extra control to the "dashboard" of the Java vehicle to help circumnavigate the synchronization pitfalls in the road.

Kris De Volder can be reached at kdvolder@cs.ubc.ca or 822-1209.



Assistant Professor of Computer Science, Kris De Volder recently came to UBC from Vrije Universiteit in Brussels.

The Man with Ultrasound Vision

Biomedical engineer Robert Rohling is blazing a trail in 3D diagnostic imaging techniques.

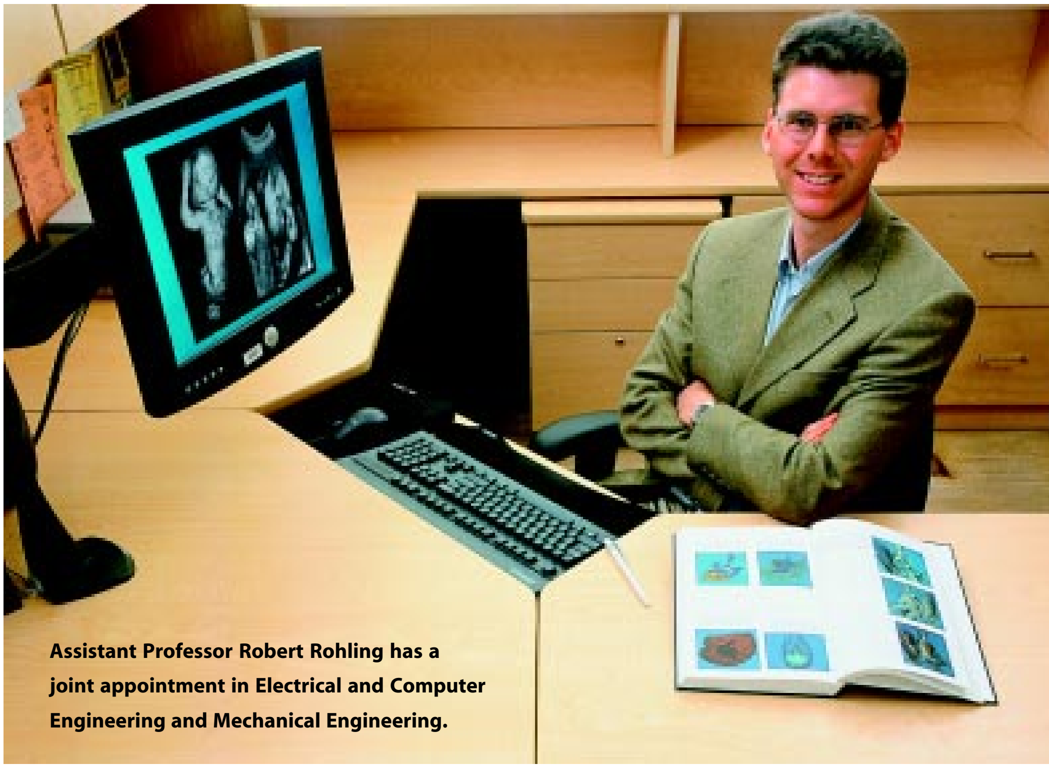
When it comes to medical imaging techniques, ultrasound is the largest growth industry. Yet there are a number of obstacles to overcome before it becomes the imaging tool of choice. ICICS member Robert Rohling is working to perfect 3D ultrasound technology. He has also developed a 3D imaging tool for hospital networks, and is helping to set new international standards for these emerging imaging technologies.

3D tool for imaging systems

Over the past several years, hospitals have been replacing film-based imaging with networks of digital archives that can be accessed by individual workstations. A doctor simply types in a patient's name to access a library of images and a variety of tools to help analyze them. At ALI Technologies, Richmond, Rohling led the development of a 3D imaging tool now widely used in Ultra PACS hospital network systems. The 3D tool uses the volumetric data sets produced by computed tomography (CT) and magnetic resonance (MR) systems to produce 3D renderings, which facilitate image identification and interpretation, diagnosis and surgical planning. Rohling recently received an ASI fellowship with matching funds from ALI to continue this work at UBC.

Ultrasound has considerable benefits over more conventional imaging technologies. It is portable, produces images of the body in real time, and is safe for both the patient and the technician. With the advent of better image processing and faster computers, the latest machines can generate very high-resolution images at one-tenth the cost of an MR machine ($100,000 to $200,000 versus $1-2 million).

While 3D ultrasound technology has been available commercially since 1989, there are still several factors that limit its usefulness and acceptance, such as accuracy and robustness of sensors, calibration, speed of reconstruction, and quality of data. Rohling has recently received NSERC funding for research that will help improve 3D ultrasound imaging.



Assistant Professor Robert Rohling has a joint appointment in Electrical and Computer Engineering and Mechanical Engineering.

The standard visualization tools now in use were developed for MR and CT, not for ultrasound. This has led to an inherent problem with ultrasound images—the appearance of speckle (a product of interference from the ultrasound echoes). It is almost impossible to filter out the noise without losing too much image detail and information. Rohling has revived an old technique, spatial compounding, to successfully "clean up" 3D ultrasound images. "If you look at the same object from different directions, the speckle pattern changes. But what you are looking at, a kidney for example, does not change," he says. When these images are averaged together the random components, or noise, tend to cancel each other out and disappear. Since the tissue components are in the same spot, they reinforce one other, highlighting the anatomical features in the image.

"The approach actually takes into account the shape and nature of the ultrasound image. It looks at how the data is created and models the curves of the data itself."

Image interpolation and reconstruction

Rohling is also working to solve problems of interpolation and reconstruction. Imagine the ultrasound volume data as a stack of images, similar to a deck of cards all slightly misaligned. "Image reconstruction becomes a mathematical interpolation problem because the data points are scattered," he notes. "In order to reconstruct ultrasound images in real time, current interpolation techniques are very simple and often ad hoc in nature." In collaboration with researchers at the National Centre for Supercomputing Applications at the University of Illinois, Rohling developed a more sophisticated radial basis function technique to analyze these large data sets.

"The approach actually takes into account the shape and nature of the ultrasound image. It looks at how the data is created and models the curves of the data itself."

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Flying Around with Computational Theory

Computer scientist Will Evans' research spans information theory, data compression and computational geometry. Trained as a theoretician at Yale and Berkeley, his work tackles some very practical software problems. Evans came to UBC from the University of Arizona, and a prior postdoc at UBC laid the groundwork for much of his current research.

Hiking the North Shore mountains provided inspiration that led Evans to develop a software tool for visualizing terrain data. TopoVista allows users to visualize elevation survey data by interactively traversing a digital surface. If you have ever dreamed of flying—and dream in colour—you will have an idea of the images that TopoVista is able to produce. Evans developed TopoVista along with David Kirkpatrick of UBC and Gregg Townsend from the University of Arizona. Former methods, such as elevation grids and triangulated irregular networks, either provided an inaccurate visual model or required too much disk space.

Right triangulated irregular networks

"I wanted something between these two methods, and that required less storage space," says Evans. "With TopoVista, users can virtually walk or fly over modelled terrain in real time while the surface changes with the position of the viewer." TopoVista uses right triangulated irregular networks, which allow a more accurate approximation of terrain data. For example, if you have highly irregular or mountainous terrain next to an open valley, data triangles in one area can easily be made smaller without changing the data triangles in the entire region (the denser the triangles, the more irregular the terrain).

Because TopoVista uses concise data sets with small space requirements, it can be used on hand-held devices. TopoVista is currently funded by the Defence Advanced Research Projects Agency (DARPA) in the US. One application appeared out of the blue—the Sea of Cortez, in fact. Researchers in Mexico are using TopoVista to visualize the ocean floor in order to study the schooling behaviour of fish. Evans notes that TopoVista would also allow people to browse geological survey data from the web. "For instance, if you want to find a meteor crater in Northern Arizona, you can now browse data sets visually."

Code compaction and code factoring

As computers and programs become more complex, compilers have been designed to produce increasingly fast code, regardless of how large the result (consider how the amount of memory on PCs has expanded). However, on small portable devices such as palm pilots and cell phones, memory is limited. Code compression, or compaction, is another practical problem that Evans is working on to try to make these devices more reliable and robust.

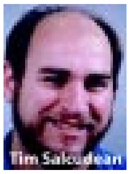
General compression facilities such as GZip require that a program be decompressed before it is executed, and this in turn requires extra storage space or execution time. In collaboration with Saumya Debray at the University of Arizona and Robert Muth at Compaq, Evans uses "compaction" to squeeze a program down to the smallest executable form. By looking at program code as a control flow versus a linear sequence of instructions, he is able to recognize similarities between chunks of code. And by identifying similar chunks of code (usually several lines long), deleting the redundant chunks and replacing them with a two- to three-line "jump and return" function, one main code group can be a accessed from different locations within the program.

This technique, called code factoring, is not yet used by most compilers. "The function calls are additional instructions that have to be executed, so we expected it to slow the process down," Evans says. "The amazing thing is that it actually sped things up in our tests." The National Science Foundation in the US is funding this work, and NSERC is funding Evans' general research.

"I'm really a theoretician, even though I'm doing all of these software-related things," he says. "I came back to UBC because I felt this was an excellent environment for doing theoretical work."

Will Evans can be reached at will@cs.ubc.ca or (604) 822-0827.

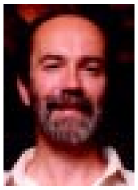
·I·C·I·C·S· Passing Notes



Four ICICS members—**Babak Hamidzadeh** (ECE), **Alan Mackworth** (CS), **Nicholas Pippenger** (CS), and **Tim Salcudean** (ECE)—and associate member **Izak Benbasat** (Commerce MIS division) are among nineteen UBC recipients of a new Canada Research Chair (CRC) announced this past spring. This funding targets experienced researchers acknowledged by their peers as world leaders or younger researchers having potential to lead in their fields. The CRC program will invest $900 million over the next five years to establish 2,000 research chairs in Canadian universities, their affiliated research institutes and hospitals. UBC's allotment of chairs placed it among the top three universities in Canada.

Rabab Ward (Director of ICICS) has been inducted as a Fellow of the Canadian Academy of Engineering. Fellows of the Academy are elected by their peers on the basis of their distinguished achievements, contributions to society and to the profession. The total number of fellows in the Academy is just under 250, out of a total of over 150,000 registered engineers across the country.

Nick Jaeger (ECE), together with his collaborators at NxtPhase, ASI and BC Hydro, has been awarded the 2001 BC Technology Industries Association Award for Excellence in Technology Innovation. Nick's work with NxtPhase in bringing a project that started in ECE to commercial fruition is an excellent example of university/industry research collaboration.



Murray Hodgson (ME) has won the 2000 Martin Heirschorn Prize from the Institute of Noise Control Engineering (USA) for a paper he published in the institute's journal.

The first class of the **Master of Software Systems** (MSS) program graduated at the spring convocation. Twenty-three students were awarded the MSS degree.

Martha Salcudean (ME Professor Emerita) was awarded an honorary PhD at UBC's spring convocation in recognition of her contributions to the university and the engineering profession.

Gregor Kiczales (CS) was one of "The Technology Review Ten" in the Jan/Feb 2001 issue of *MIT's Magazine of Innovation Technology* for his work on "Untangling Code." See www.techreview.com/magazine/jan01/tr10_kiczales.asp

James Olson (ME) has received the Weldon medal from the Pulp & Paper Technical Association of Canada (PAPTAC) for the best paper at a PAPTAC-sponsored conference for the year 2000.

Mohamed Gadala (ME) has been named the Patrick Campbell Chair in Mechanical Engineering Design. The chair was made possible by a generous donation from Mr. Patrick Campbell, an ME alumnus. Gadala will take a leading role in the development and presentation of the design curriculum at the undergraduate and graduate levels.

Hodgson, *continued from page 3*

surgical instruments, and validating surgical simulations used in training and assessing a surgeon's motor skills.

"Performing laparoscopic surgery is described as trying to tie your shoelaces with chopsticks," says Hodgson. Current tools provide four degrees of freedom (normal movement has six). However, with every degree of freedom the complexity of the technology increases significantly. "We found out that four degrees of freedom is sufficient even for complex tasks such as suturing if you can give surgeons the impression that their hands are inside the patient," he says. One of his goals is to design an inexpensive instrument with this capability.

The other major question he is trying to answer is does practice on a simulator really improve performance in the OR? "Nobody really knows the answer yet," he says. "The ICICS initiative will help me work with haptics specialists like Karon MacLean in Computer Science to figure this out."

Antony Hodgson can be reached at ahodgson@mech.ubc.ca or (604) 822-3240

Rohling, *continued from page 5*

However, most techniques are developed for 100 to 1,000 data points and Rohling uses between one and ten million. While his technique is slower than others, it has set a gold standard for image quality. "The challenge now is to find the middle ground," he says.

Rohling's other challenge is to help standardize how data is shared and displayed on medical imaging machines across networks and from various manufacturers. Currently, there is no Digital Imaging and Communications in Medicine (DICOM) standard for 3D ultrasound. The other problem is simply the amount of information. "Ten years ago a typical CT study might have 12 images. Today, it can have up to 3,000," says Rohling. Networking and workstation technologies have not increased in speed and performance as fast as the medical device manufacturers are creating data. "A large part of my work is to help devise a standard that everybody can agree upon and that will accommodate the needs of the future."

Robert Rohling can be reached at rohling@ece.ubc.ca or (604) 822-2045.

2001-2002 ICICS Distinguished Lecture Series

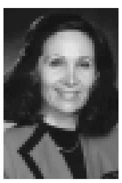
Gerd Hirzinger

Kristen Nygaard

Hiroshi Ishii

Henry Levy

A. Galip Ulsoy



Claudine Simson

ICICS is hosting the 13th annual Distinguished Lecture Series, bringing in academic and industrial leaders in the forefront of their fields.

Lectures will be held from 4:00 to 5:30 pm in the CICSR/CS building, room 208, 2366 Main Mall, UBC, and there is no charge. For more information call (604) 822-6894.

DATE	SPEAKER
September 27, 2001	**Towards a New Robot Generation—from Space to Surgical Applications** **Gerd Hirzinger** • Deutsches Zentrum für Luft- und Raumfahrt, Germany
October 25, 2001	**Basic Concepts in Object-Oriented Programming** **Kristen Nygaard** • Universitete I Oslo, Norway
November 29, 2001	**Tangible Bits: Towards a Seamless Interface Between People, Bits & Atoms** **Hiroshi Ishii** • MIT, MA
January 31, 2002	**Doubletalk: From Web Access Patterns to Multithreaded Processors** **Henry M. Levy** • University of Washington, WA
February 28, 2002	**Reconfigurable Manufacturing Systems** **A. Galip Ulsoy** • University of Michigan, MI
March 28, 2002	**Science and Technology Innovation in a Global Knowledge-Based Economy** **Claudine Simson** • Nortel Networks, ON

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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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