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

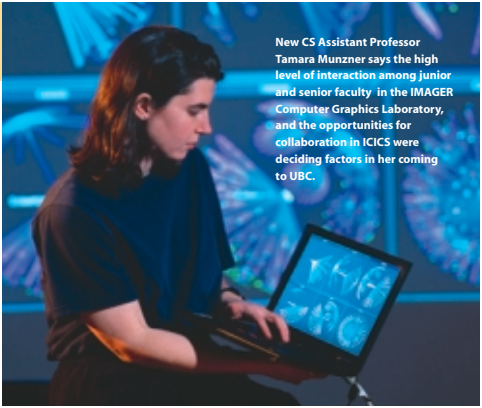
ICICS FOCUS

THE UNIVERSITY OF BRITISH COLUMBIA

Visualizing Abstract Information

- Information Visualization
- Spatialising Data
- Computer Graphics

Growing computational power and burgeoning data sets bombard us with more information than we can easily comprehend. Tamara Munzner's work in information visualization (infovis) applies computer graphics and the human visual system to help users explore and explain data.



New CS Assistant Professor Tamara Munzner says the high level of interaction among junior and senior faculty in the IMAGER Computer Graphics Laboratory, and the opportunities for collaboration in ICICS were deciding factors in her coming to UBC.

Ever since prehistoric humans began painting petroglyphs, visual metaphors have been used as powerful cognitive tools. "What the computer provides that thousands of years of graphic design does not—is interaction," says Tamara Munzner, who recently came to the department of Computer Science at UBC from Compaq's research centre in Palo Alto, California.

Munzner uses the computer as an interactive visualization tool to help us make meaning out of data. Designing a plausible synthetic information space that a user can easily comprehend and navigate is a major challenge, particularly when it involves interacting at a guaranteed frame rate in real time. Information visualization, or "infovis," is an emergent and highly interdisciplinary research area, which draws on concepts from computer graphics, human-computer interaction, cognitive psychology, semiotics, graphic design, cartography, and art. Munzner notes that after ten years, infovis has become recognized as a field in its own right.

"Spatial perception is the strongest of our visual cues," says Munzner. "So choices about spatialising the data are the most critical." Once she comes up with a spatial concept, the next step is to scale it to a large data set. Another challenge is designing algorithms to determine what element is most important in a scene, particularly when everything is abstract to begin with.

Seeing the Forest and the Trees

Munzner is interested in building systems that show both focus and content at once. "The idea is to have detail and overview in the same view, and to have some kind of carefully chosen distortion that allows you to merge them," says Munzner.

Continued on page 2

ICICS

Spring 2003 Vol. 14. No. 1

ICICS Director's Corner

This expanded issue of *FOCUS* illustrates how quickly our ICICS team is growing—and the vitality of their collaborative work within ICICS and with other industry and university researchers across Canada.

Tamara Munzner (CS) is a pioneer in the emergent field of information visualization (infovis), which draws on concepts from computer graphics, human-computer interaction, cognitive psychology, semiotics, graphic design, and cartography. She collaborates with several ICICS members and researchers across Canada to build tools to help us explore and explain data.

Shahriar Mirabbasi's (ECE) work in mixed-signal integrated circuits facilitates System-on-a-Chip design. His research in micro-power wireless transceivers involves collaboration with Chemical and Biological Engineering, Agricultural Sciences and Fisheries in the development of animal tagging.

Linguist Bryan Gick studies the motor processes involved in making speech. His work has applications in speech recognition and synthesis, speech pathology and surgery.

In a special foldout section, we introduce eleven new ICICS members and offer brief synopses of their research activities. Look for in-depth profiles of these dynamic newcomers in upcoming issues of Focus.

The work of Panos Nasiopoulos (ECE), who directs research in rich media transmission and interactivity in the Midnet Lab, is also featured in this issue. Panos directs the ICICS Master of Software Systems Program in addition to his research activities.

An expert in fluid mechanics and aerodynamics, Sheldon Green's (ME) work improves the instruments used in pulp and paper manufacture. He is also helping to develop new meteorological instrumentation in collaboration with Atmospheric Sciences and other ME faculty.

Rabab Ward, ICICS Director

Munzner: ***Continued from page 1***

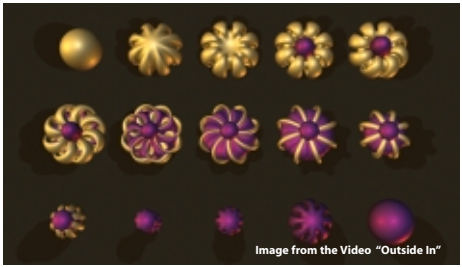


Image from the Video "Outside In"

She plans to collaborate with ICICS member Ron Rensink (of CS and Psychology) to investigate how much a scene can be manipulated through operations such as translation, rotation, and scale before pre-attentive visual interpretation breaks down, and users have to re-acquire the scene in order to make sense of it.

Key Collaborations

With funding from GEOIDE, a federally supported Networks of Centres of Excellence, Munzner and other researchers across Canada are working to see how effectively they can augment geospatial data from geographic maps with an abstract view that includes more semantic or interpretive data. At UBC, this project includes the Sustainable Development Research Initiative, Forestry's Michael Meitner and Stephen Sheppard. She is also discussing a new project on the visualization of data mining with Raymond Ng of CS.

"With infovis, the more users you have who can provide feedback, the better off you are in terms of being able to understand what the problem is, so you can design something better next time."

Munzner is also keen to apply her work to evolutionary biology and bioinformatics. "What is appealing about bioinformatics problems is that they have three things going for them: big data sets, clear problems, and funding," says Munzner. "It is difficult to find all three together."

Using Geometry to Get the Picture

Tamara Munzner honed her skills in visualization at the NSF-funded Geometry Centre in Minneapolis. There, she helped develop the video "Outside In," which uses sophisticated computer animation to demonstrate a famous mathematical hypothesis in topology—how to turn a sphere inside out without puncturing or tearing it.

After working in the specialized area of mathematics visualization, she began PhD work at Stanford in information visualization, and also consulted with Silicon Graphics, where she developed software to help web designers visualize the hyperlink structure of a large website in its entirety, rather than one page at a time. "The interesting aspect of this work is trying to understand the user's path by overlaying web trail traffic on top of site structure," says Munzner.

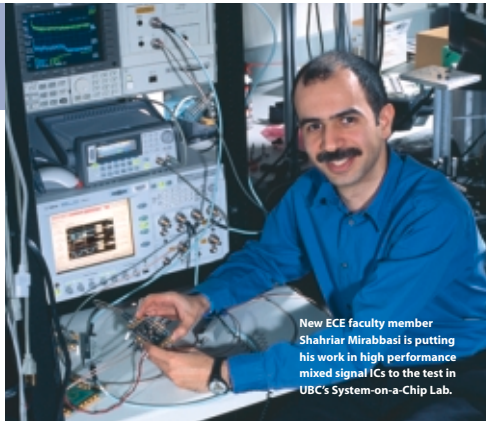
Munzner has developed several infovis software tools. She says that working in industry gave her invaluable experience with real-world data sets. "When you build the systems that you want people to use, you run up against hard problems, and scalability and usability are just two of them."

Tamara Munzner can be contacted at 604-827-5200 or tmm@cs.ubc.ca

Crossing the Digital Divide

Affordable access to increasing amounts of data—anywhere, anytime—challenges researchers like ECE assistant professor Shahriar Mirabbasi. His work in mixed-signal integrated circuit (IC) design aims at helping the microelectronic industry meet this need.

- **Integrated Circuit Design**
- **Wireless/Wireline**
- **System-on-a-Chip**
- **Micro-Power Animal Tags**

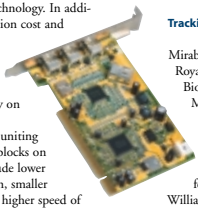


New ECE faculty member Shahriar Mirabbasi is putting his work in high performance mixed signal ICs to the test in UBC's System-on-a-Chip Lab.

Advances in digital IC fabrication have produced digital circuits that are more robust and flexible than their analog counterparts. For new ICICS member Shahriar Mirabbasi, there is one main snag in this shift to digital—most physical signals that are transmitted or received are still analog in nature. Implementing more functionality in the digital domain demands more stringent performance requirements on analog and mixed analog-digital interface blocks. These mixed-signal blocks are the major bottleneck in the technology—one that Mirabbasi is working to unplug.

System-on-a-Chip (SoC)

In UBC's System-on-a-Chip (SoC) Lab, Mirabbasi collaborates with fellow researchers to improve the performance of integrated mixed-signal microchips. The technology of choice for system-on-a-chip implementation is silicon-based CMOS (Complementary Metal-Oxide Semiconductor) technology. In addition to low fabrication cost and high yield, CMOS provides the possibility of integrating analog and digital circuitry on the same chip.



Advantages of uniting analog and digital blocks on the same chip include lower power consumption, smaller package size, and a higher speed of operation. Designing analog and digital circuits on the same substrate introduces subtle challenges. Analog circuits require a quiet environment; however, different switching activities in the digital circuitry cause a "noisy" environment and corrupt the sensitive analog signals.

Tracking Steller Sea Lions

Mirabbasi also collaborates with Royann Petrell (Chemical and Biological Engineering), Scott McKinley (Agricultural Sciences), Andrew Trites (Marine Mammal Unit, Dept. of Fisheries), and fellow ICICS members William Dunford and Matt Yedlin (both of ECE) on the design and implementation of micro-power wireless transceivers for animal tagging. With funding from the North Pacific Universities Marine Mammal Research Consortium, National Oceanic and Atmospheric Administration (NOAA), and North Pacific Marine Science Foundation, they are developing a tiny biotelemetry device for tracking Steller sea lions. Designing reliable, low-voltage, low-power, high-speed mixed-signal ICs is crucial to the construction of tags with battery longevity.

This research also has biomedical applications, such as for pacemakers and other implants. "You don't want to implant something inside the body that consumes excessive power," says Mirabbasi. "This not only shortens battery life, but also causes the implant to heat up."

Continued on page 9

Modelling the Manner of Speaking

Linguist Bryan Gick's research on the mechanisms of speech production gives new meaning to the phrase "read my lips."

- **Vocal Tract Modelling and Synthesis**
- **Speech Motor Control**
- **Ultrasound Imaging**

"We haven't really understood the whole speech motor control system —just because it is so difficult to get at."

How do we make the sounds needed for articulate speech? How do those sounds differ between languages? And how can we track the movement of the mouth, lips and vocal tract to model those sounds and reproduce them digitally? "Understanding how we acquire and use language is all part of learning more about how the mind works," says Bryan Gick, assistant professor in Linguistics and founding director of UBC's Interdisciplinary Speech Research Laboratory.

Bryan Gick studies the motor processes that go into making speech sounds, such as constrictions of the vocal tract, and movement of the tongue, mouth and lips to understand how we control our articulators in order to be able to measure and model them.

"Once we begin to understand what humans can do with their vocal tracts, then we start to understand things about speech in general," says Gick. His work has potential applications in speech recognition and synthesis, speech pathology, linguistics, and surgery.

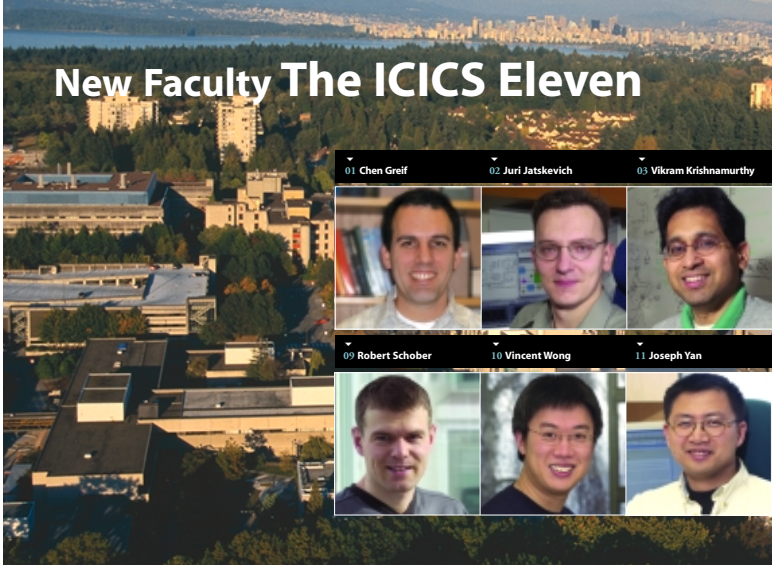
The Measure of Speech

Gick and his collaborators have developed techniques for using ultrasound imaging to measure the tongue during speech production. They plan to create more complete vocal tract models by first using MRI to get a static image of the vocal tract, into which they can then insert ultrasound images of tongue movement. They also combine video signals from the ultrasound with video of the face to track lip and head movement. Converting vocal tract shapes into sound further involves modelling the complex aerodynamics of breath, or turbulence, in the vocal tract. This turbulence is what makes "thhh" and "shhh" sounds.

Gick's work in vocal tract modelling with fellow ICICS member Sid Fels of ECE was presented by graduate students Florian Vogt and Ian Wilson at the 2001 Advanced Systems Institute (ASI) Exchange, where it won a Communication Award. Gick notes that coupling vocal tract with face simulation has an important potential application in telecommunications, because it reduces the amount of bandwidth needed for audiovisual transmission. "If you have a single synthesis system, where you track very basic movements and the entire head is modeled as one object, then if you send one set of parameters for speech, the face, mouth and lips all move in tandem."

Bryan Gick can be contacted at 604-822-4817 or gick@interchange.ubc.ca

New Faculty The ICICS Eleven



01 **Chen Greif,** CS. Research: Scientific computing. "Many mathematical problems can be solved numerically by using powerful computers. The rapidly growing computing power available even on today's simplest home PCs makes this research area all the more dynamic and exciting. I am interested in investigating and implementing efficient numerical solution techniques for problems arising in computer science, mathematics and engineering."

02 **Juri Jatskevich,** ECE. Research: Computer simulation of electrical systems. "Power electronics play an increasingly important role in the performance and reliability of modern aircraft, ships and vehicles, as well as ground electric power systems. Simulation is key in achieving the design goals. I am interested in how we can reduce the time required to simulate and analyze complex systems."

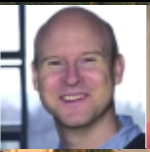
03 **Vikram Krishnamurthy,** ECE. Research: Statistical signal processing. "The suppression of noise and optimization of systems that evolve randomly are crucial in the design of new generation cell phones, PDAs, radar systems, and sophisticated electronic warfare systems. My goal is to devise and analyze high performance statistical signal processing algorithms for these complex systems."

04 **John D. Madden,** ECE. Research: Molecular actuators and devices. "A key aim of my research is the development of muscle-like motors, made of electronically conducting polymers that change dimension as their chemical state is altered. An interesting application is their use in powering the flight of insect-sized vehicles (in collaboration with Joseph Yan, ECE). I am also investigating the ability of these polymers to store and rapidly release tremendous quantities of electrical charge, a property that is potentially useful in fuel-cell-driven vehicles. In order to fully realize the potential of super-capacitors and polymer motors, fabrication methods are being devised that enable the structure to be controlled at nanometre-length scales."

05 **Joanna McGrenere,** CS. Research: Human-computer interaction. "From desktops to laptops, PDAs, cell phones, and embedded devices—all this technology was supposed to make our lives easier and yet even I am often flummoxed by it! My goal is to factor the human element into the design of technology. In particular, I am investigating adaptive and adaptable interface designs as complementary yet competing approaches to accommodating individual differences among users."

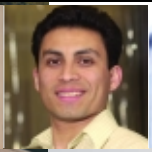
11

04 John D. Madden

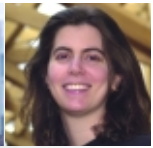


05 Joanna McGrenere

06 Walter Mérida



07 Shahriar Mirabbasi



We welcome the eleven talented scientists who have recently joined the ICICS team. These cv-snapshots provide a glimpse into the research they are doing and illustrate current and potential creative collaborations —the focus of ICICS's mandate.

06 **Walter Mérida,** ME. Research: Proton exchange membrane fuel cells. "My research focuses on clean energy sytems. We must strive towards energy systems that are sustainable and geopolitically stable. My overall research strategy is focused on fuel cell and hydrogen technologies. The goal is to allow renewable energy to complement our current dependence on fossil sources. To this end, I am interested in finding collaborators at ICICS to model the fundamental processes in a fuel cell."

07 **Shahriar Mirabbasi,** ECE. Research: Analog and mixed-signal integrated circuit design. "In the current information age, 'digital' is the buzz word; however, most physical signals are analog in nature. Designing high-speed, low-power analog and mixed analog-digital circuits is an engineering art that we are trying to master."

08 **Tamara Munzner,** CS. Research: Information visualization. "I build systems to help people understand large datasets using interactive computer graphics. In the past I've worked with people ranging from topologists and cognitive linguists to web-site designers and networking researchers. I'm enthusiastic about starting new collaborations at UBC, especially within ICICS, in bioinformatics and other areas."

09 **Robert Schober,** ECE. Research: Wireless communication. "My research goal is to design and analyze efficient algorithms that enable high-data-rate wireless communication and have an affordable computational complexity. Applications of my research include second and third generation mobile communication systems, Bluetooth, and wireless local area networks (WLANs)."

10 **Vincent Wong,** ECE. Research: Wireless networking. "My research interests include scheduling and topology discovery in wireless personal area networks, routing in wireless mobile ad hoc networks, and handoff and location management in wireless cellular networks. As an ICICS member, I am looking forward to the opportunities for collaboration that the Institute provides."

11 **Joseph Yan,** ECE. Research: Micromechatronics systems. "I research micromanipulation and microassembly tools as an enabling technology for the fabrication of micromechatronic systems. I am particularly interested in using these tools for the development of biomedical devices. Another exciting part of my research is biomimetic robotics, in which the design of machines is inspired by biological systems which are adapted to similar tasks or environments (e.g., a centimetre-scale robot achieving flight using flapping wings, like biological insects)."

The Big Squeeze:
Digital Multimedia Sends the Most Using the Least

- **Interactive Multimedia**
- **Video Broadcasting and Streaming**
- **Digital Video Security**

Panos Nasiopoulos directs research in the Midnet lab, an important funding source for this ICICS member, where researchers work to enable rich media transmission and interactivity using new wireless networks and high definition television broadcasting systems. "Two big challenges when transmitting multimedia information include bandwidth fluctuation across wireless networks and processing power on receiver units," says Nasiopoulos. "Another challenge is how to protect digital media from piracy. These are the problems we are working on in the Digital Multimedia Lab at ECE."

Digital Video for Wireless Communications

As an associate professor at the department of Electrical and Computer Engineering, Nasiopoulos refines algorithms to make transmission of large amounts of video, audio and graphic information possible across third generation (3G) wireless networks. Random fluctuations in the available bandwidth per user present the primary challenge to video transmission over wireless networks. In addition, the size and cost limitations of low-end processors embedded in mobile units severely limits the complexity of decoder algorithms.

"Our research centres on the emerging video coding standard, H.264," says Nasiopoulos. The H.264 codec enables delivery of Internet Protocol-based broadcast-quality video at data rates of less than 1 Mbit/second. The lab is developing techniques that enable H.264 to adapt to the instability of network bandwidth, with the goal of adjusting video quality in real time, increasing the error resilience of the overall system and reducing the decoding complexity for mobile processors.

Viewer-controlled TV Programming

Interactive television (ITV) changes the way TV viewers experience entertainment, by giving them the ability to control programming content. Today, ITV refers to technologies that integrate the world wide web with television programs. A web page is displayed beside the video on the TV screen, which provides further information or graphic enhancements. This technology is limited since it does not allow users to actually control a show's video or audio content. ICICS Digital Multimedia researchers have developed services for ITV that provide DVD-like interactivity for viewers, allowing them to actually control the visual content of the TV program.

"We're looking for methods which add the extra video and audio streams containing interactive content to the transmission lines of digital TV systems without increasing bandwidth or degrading the quality of the main video and audio streams," says Nasiopoulos.

Continued on page 9

Panos Nasiopoulos is a busy man; he also directs the Master of Software Systems program at ICICS, a program unique in Canada.

Following the Flow

Sheldon Green develops new instrumentation to measure subtle interactions in fluid mechanics and aerodynamics.

- **Fluid Mechanics Instrumentation**
- **Pulp Fibres, Fibre Mats**
- **Papermaking**

"This new force balance allows one to accurately measure small forces in the presence of much larger forces," says Green. "Often, a large load confounds the measurements of a much smaller load."

Last summer, Sheldon Green undertook a kayaking expedition to Alaska, where he paddled more than 700 nautical miles in two months. A kayak is a responsive, sensitive boat—a fitting craft for Green, who develops finely-tuned instruments that can measure subtle interactions in fluid mechanics and aerodynamics.

Green, an ICICS member and professor of Mechanical Engineering, is currently interested in improving the instruments used in pulp and paper making. He and graduate student Tze Bun Wong are pursuing the holy grail of industrial papermaking: a device that accurately measures and separates fine, high-value pulp fibres from their coarser, lower-value cousins.

Measuring High-Speed Fibre Flows

Knowing how wood fibres of differing quality behave in the hydrocyclone—a critical component of papermaking machines where wood fibres are separated—could lead to improvements both in how the fibres are used and in the ways the machines are designed and operated. Fine "earlywood" fibres, for example, could be streamed into paper production, while coarser "latewood" fibres could be used for fibreboard.

"We have developed the first device capable of measuring the hydrodynamic characteristics of individual pulp fibres."

Another papermaking instrument that Green is working on measures the characteristics of fibre mats, created in the early stages of the paper making process. The manufacturing process of this initial form of paper—which involves spraying watery fibre pulp between two porous "forming fabrics" and then squeezing out the water takes a tenth of a second. Green and co-op students Willa Duplantis and Larry Li have built a bench-scaled device that simulates the nearly instant formation of a fibre mat in a papermachine. With this instrument they can observe and measure the movement of water and the formation of mats at the same operating speeds as most modern papermaking machines— speeds too high for most existing measuring devices. "An early prototype of the instrument has now been modified to simulate the pulp shearing that occurs in real papermachines. It is as close to real life as one can achieve without replicating the entire forming section of a papermachine," says Green.

Continued on page 9

Mirabbasi: ***Continued from page 3***

The Limits of CMOS

Designing mixed-signal chips for wireless and wireline communications with robust performance at high frequencies is a key aspect of Mirabbasi's work. As a cost-effective technology for integrated circuits, CMOS is used for a variety of applications, such as wireline or wireless communications. However, the demand for faster data rates is pushing ICs to operate at higher frequencies.

"We are trying to see how far we can improve the performance of mixed-signal circuits implemented in standard digital CMOS technology, without having to add costly analog fabrication options," says Mirabbasi. "Eventually, CMOS will be unable to function as we move to higher and higher operating frequencies." He is looking at other technologies, such as silicon germanium, but notes the difficulty in replacing a technology that is already entrenched in the marketplace.

"You don't want to implant something inside the body that consumes excessive power. This not only shortens battery life, but also causes the implant to heat up."

Shahriar Mirabbasi can be contacted at 604-827-5218 or shahriar@ece.ubc.ca

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Nasiopoulos: ***Continued from page 7***

Digital video watermarking

Protecting Content Against Piracy

Unfortunately, the ease with which end users can produce digital copies, which maintain the perfect quality of the original, has become a serious piracy issue for multimedia content developers and a growing concern for TV broadcasters.

Digital video watermarking uses the inherent properties of digital images, with the limitations of human vision, to insert invisible data into digital video to provide copyright protection. The watermark tracks pirated copies, prevents illegal copying and authenticates digital data. In the multimedia lab, Nasiopoulos and others are developing real-time video watermarking solutions for DVD and digital TV applications, by taking advantage of some of the inherent features of the MPEG-2 and H.264 video compression standards. This includes motion compensation between consecutive frames and distribution properties of frequency coefficients, to create watermarks in areas imperceptible to the human eye.

Nasiopoulos' vision is to establish the Midnet lab as the neutral ground upon which discussions can be held among major corporations and researchers to set world standards in multimedia communications.

See the Master of Software Systems website at www.icics.ubc.ca/mss/

Panos Nasiopoulos can be contacted at 604-822-2646 or panos@ece.ubc.ca

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Green: ***Continued from page 8***

Measuring Drag to Improve an Athlete's Speed

Green is also interested in improving instrumentation used in aerodynamics; specifically, he is working on a new force balance for use in wind tunnels. Nike Canada recently used the instrument to determine the drag of different fabrics on athletic performance in a series of wind tunnel tests.

Olympic skeleton racers have also used the balance to reduce their drag—and increase their speed during runs.

Collaboration with ICICS members is an important element of Green's work, as evidenced by the number and breadth of projects he is involved in.

He is working with Carl Ollivier-Gooch (ME) to measure the subtle performance characteristics of the ducted tip propeller, with Gary Schajer (ME) and Roland Stull (Atmospheric Sciences) to develop new meteorological instrumentation, with James Olson (ME) to study papermachine forming fabrics, and with Ian Frigaard (ME) to examine the non-Newtonian flows of oil-drilling muds.

Currently, Green is on sabbatical at Monash University in Melbourne, Australia, where he pursues his papermaking instrumentation research at the university's renowned Australian Pulp and Paper Institute. He returns in June, when he will perhaps have time again to launch his kayak into the waters of the Pacific Northwest.

Sheldon Green can be contacted at 604-822-5562 or green@mech.ubc.ca

Passing Notes:

Provincial Government funds "Doubling the Enrollment" (DTO) initiative at UBC

UBC will receive $46 million in provincial funding for facilities to support students in high-tech programs, specifically 455 new undergraduate spaces in Computer Science and 652 spaces in Electrical and Computer Engineering to be added by 2006/07. The funding will also provide an additional 204 graduate spaces. The physical expansions of ECE and CS will be in close proximity to the new ICICS building, which is to be completed as of December 2004.

"Due to the strength of this commitment by the Provincial Government, we can further our aim of fostering research and collaboration among the best academics in Canada here at ICICS," says **Rabab Ward**, Director of ICICS. "As information and telecommunication technologies become ubiquitous, the expansion of the ECE and CS programs will give ICICS a great boost in the pursuit of cutting edge research into technologies that serve people and society at large."

Advanced Systems Institute recognizes outstanding UBC grads

ICICS and the BC Advanced Systems Institute (ASI) awarded 16 scholarships to UBC Applied Science graduate students on October 17, 2002. ICICS grad students again did very well at the ASI exchange on March 11, 2003. The winners of the ASI Communication Award are **Charles Boivin, Iman Brouwer** and **Ann Nakashima** from ME, and **Ashley Gadd, Dave Tompkins** and **Amy Yan** from ECE.

Killam teachers awards goes to two ICICS members

The prestigious 2003 UBC Killam Teaching Prizes for the Faculty of Applied Science are to be awarded to ICICS members **Dr. Steve Wilton**, associate professor in the department of Electrical and Computer Engineering, and **Dr. Tony Hodgson**, associate professor in the department of Mechanical Engineering. ICICS congratulates both Steve and Tony on their outstanding teaching and on being awarded these prestigious prizes.


Steve Wilton


Tony Hodgson

This year's other nominees were all viewed by the committee as outstanding educators, making its choice of only two prizewinners a difficult one, and thus all the nominees should be congratulated.


Vinod Modi

World renowned aerospace engineer Vinod Modi dies February 12, 2003

Dr. Vinod Modi, professor emeritus of Mechanical Engineering and long time ICICS member, passed away on February 12, 2003. Dr. Modi joined UBC in 1961; he became professor emeritus in 1995. Dr. Modi's contributions to the field of aerospace engineering, aerodynamics, dynamics of ocean based systems and biomechanics are recognized worldwide. His versatility was reflected by research into areas as diverse as the human heart, offshore oil platforms, V/STOL airplanes, wind energy, ground vehicle aerodynamics, control of the proposed Space Station and mobile robotic manipulators. He is the author of more than 500 technical publications on these subjects. Dr. Modi served as a consultant to a number of industrial and government agencies, including the United Nations. His contributions were recognized by thirty awards, won from 1981 to 2002. He was also an award-winning photographer, once raising $32,000 in the sale of his photographs for the National Association of the Blind. He will be very much missed by friends and colleagues here at ICICS.

•I•C•I•C•S• Institute for Computing, Information and Cognitive Systems www.icics.ubc.ca

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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