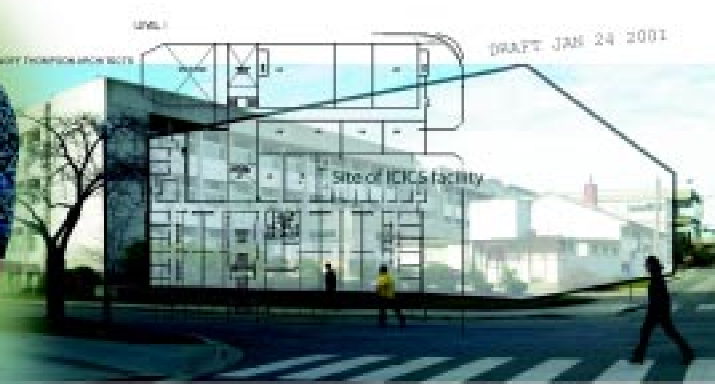
CENTRE FOR INTEGRATED COMPUTER SYSTEMS RESEARCH

CICSR

FOCUS

THE UNIVERSITY OF BRITISH COLUMBIA

ICICS—Exploring Human Experience to Create Better Technology



Some of the key ICICS investigators left to right, front row: Rabab Ward, Jim Varah, Sid Fels, KD Srivastava. Back row (l-r): Nick Pippenger, Raymond Ng, Alan Mackworth, Dale Cherchas, Kelly Booth, Clarence de Silva, and Victor Leung.

$22 million in funding is transforming CICSR into ICICS, UBC's Institute for Computing, Information & Cognitive Systems

When we sit down at our computer in the morning, it is difficult to imagine that less than twenty years ago PCs and laptops didn't exist. The fax machine was revolutionary. Newspapers were still typeset by hand. Like any relationship, the one between humans and computers has had its ups and downs. Computers and related technology have transformed the way we work, communicate, create, learn, and play. They have increased productivity, put a wealth of information at our fingertips and connected us across the globe. They have also increased workloads and learning curves, caused repetitive strain injuries, and led to isolation and new addictions. For better or worse, they are now an integral and increasingly intrinsic part of our lives. During the past two decades, humans have been scrambling to catch up, keep up and adapt to new technologies.

To transform the way we use, design and interact with machines and technologies requires a major conceptual shift—one that focuses on studying, understanding and communicating human experience. "ICICS will foster collaborations between researchers from all disciplines, particularly those studying health, emotions, social interactions, and our relationship with the environment," says principal investigator Rabab Ward. It is a vision that is strongly supported. The ICICS proposal received over $22 million in funding: $8.85 million from the Canadian Foundation for Innovation (CFI), matched by $8.85 million from BC's Knowledge Innovation Fund, and $4.5 million from UBC's Blusson Research Fund.

ICICS spans all disciplines

The process of writing the proposal took over a year and a half, and involved more than 80 faculty members. Jim Varah, professor of Computer Science, and KD Srivastava, vice-president emeritus and former ECE head, both helped author the proposal (which had 10 senior applicants and 120 co-applicants). Not only was the initiative lauded for its innovation and vision, the breadth of disciplines involved will make ICICS one of the most comprehensive and

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Spring 2001 Vol. 12, No. 1

CICSR
Director's Corner

Anne Condon (left) and Rabab Ward

Computer Science professor and CICSR member Anne Condon (profiled in *Focus*, Spring 2000) is currently the Acting Director of CICSR while I am on sabbatical. Anne has agreed to take on these extra responsibilities during an exciting time. In fact, we have so much news that we have expanded this issue of *Focus* to twelve pages.

The biggest story is CICSR's transformation into ICICS. With $22 million in funding from CFI, the Province and UBC, our research will now involve collaboration with disciplines from across campus. The cover article and inside spread describes the process, the initiative, the infrastructure, and some of the groundbreaking work that is being conducted under the ICICS umbrella.

The other major story is about people—the talented new faculty members that have recently joined CICSR. Most have come to UBC from academic or industry positions in Europe and the US. This issue features Ian Frigaard (non-Newtonian fluid dynamics), Wolfgang Heidrich (interactive computer graphics), Holger Hoos (artificial intelligence, computational musicology, bioinformatics), Tim Menzies (artificial intelligence), Ron Rensink (computational studies and psychophysics), Resve Saleh (System-on-a-Chip), and new ME head Nimal Rajapakse (smart materials). You will also read about a CICSR/UBC spin-off success story, Point Grey Research. Their work in computer vision technology is capturing the attention of companies worldwide.

Rabab Ward, CICSR Director

New ME Head Pioneers Smart Structures

"This is a dynamic department with a great group of colleagues, excellent students and very helpful staff."

When he speaks of "active control," Nimal Rajapakse is referring to an essential feature of smart structures. But the term could also apply to his philosophy of work and life. UBC's new head of Mechanical Engineering is committed to the core values of his job: excellence in teaching and research, innovation and collegiality. In 2000, the Canadian Society for Civil Engineering awarded him the Horst Leipholz Medal for his outstanding contributions to engineering mechanics research.

Rajapakse came to UBC from the University of Manitoba, where he was also department head. "This is a dynamic department with a great group of colleagues, excellent students and very helpful staff," he says. "Research today is increasingly interdisciplinary and ICICS's infrastructure really supports this." Rajapakse's research—modelling of adaptive (smart) materials—involves continuum mechanics, material science, physics, and mathematics, as well as extensive computer-aided simulation.

Smart structures sense and adapt to change through a system of embedded sensors and actuators made out of adaptive (smart) materials. These structures are of particular interest to the defence and aerospace industries, which are committing considerable funding to this area of research, particularly in Europe, Japan and the US. NSERC and Manitoba Hydro have been funding Rajapakse's smart structures research since 1995.

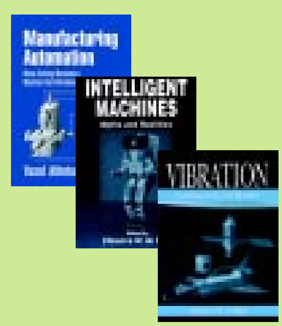
Rajapakse's particular area of expertise is in piezoelectric/ferroelectric solids, crystalline materials that exhibit unique behaviour under mechanical loading (pressure) or the application of electricity. When subjected to pressure they create electricity (this is the concept behind sensors). Conversely, subjecting these solids to an electric field generates a strain in the material (the concept behind actuators). Since they can be used as both sensors and actuators, piezoelectric solids are very important to the design of smart structures. They are also used in thin film applications involving microelectromechanical systems.

One example of these applications is helicopter blades with embedded piezoelectric actuators for adaptive shape (camber) and vibration control. Another is the active control of vibrations in space structures. Smart materials also have important applications in civil engineering, particularly in structural problems related to earthquakes. They could also provide a more comfortable driving experience. "A smart suspension system in a car could sense the profile of the road and provide better control and comfort," says Rajapakse, referring to a recent application of piezoelectric ceramics by a leading automaker. Smart skis can even take the edge off of moguls. **Nimal Rajapakse is at rajapakse@mech.ubc.ca or at (604) 822-0497**

Recent books by CICSR members

Yusuf Altintas, *Manufacturing Automation: Metal Cutting Mechanics, Machine Tool Vibrations, and CNC Design* (Cambridge University Press, 2000).

Clarence de Silva, *Intelligent Machines—Myths and Realities* (CRC Press, 2000); and *Vibration—Fundamentals and Practice* (CRC Press, 2000).



Spearheading System-on-a-Chip

Resve Saleh's mission is to create a world-leading research centre for System-on-a-Chip design, testing and verification.

The widening gap between technology and productivity is fuelling a revolution in silicon chip design. Advances in deep submicron technology (DSM) have escalated the amount of logic, circuitry and functions that can be designed into chips. Currently, hundreds of millions of transistors can be put on a single chip, and this is predicted to increase to one billion before the end of the decade. "The problem is the number of transistors that designers can build in a day is not increasing significantly," says Electrical and Computer Engineering professor Resve Saleh. He believes we need to change the way chips are constructed to solve this productivity gap.

Resve Saleh is a member of the International Roadmap of Semiconductors Committee.

Challenges to SoC

The concept of System-on-a-Chip (SoC) is simple. A computer chip is made up of several blocks, many of which perform standard functions. Instead of redesigning the blocks that control functions such as memory, interface blocks and processing units, they would be reused. However, there are several hurdles to overcome before SoC is feasible. Since technology changes so rapidly, what works on today's design may not work on subsequent ones. And the concept of reuse is not built into chip design because of the cost, effort and the time it takes to get to market.

Another challenge to SoC is the technology itself. Designers have to work at a higher level of abstraction. Putting transistors closer together and driving more current through them results in more coupling and substrate noise and other undesired electrical effects.

"The next generation of designers must understand what's going on both at the system level, and at the silicon level," says Saleh. In order to train designers to work in SoC, his current course in DSM integrated circuit design will become a permanent part of the curriculum.

Perhaps SoC's biggest challenge is integrating digital and analog components on a single chip. More analog blocks are required for wireless, LAN and packet processing applications, and analog requires more voltage and different processing optimization than digital circuitry. It also works best in quiet environments. Digital circuitry, which constantly switches from low to high voltage, is very noisy. "David Pulfrey of the SoC group is exploring these issues in his research," notes Saleh.

> **"Just putting things on a chip and hooking them together doesn't guarantee that it will work. In fact, right now it probably guarantees that it won't work."**

QoS and programmable IP

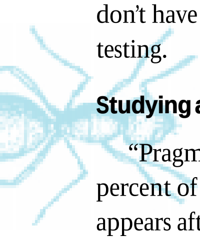
Designing reusable intellectual property blocks involves issues of legality, licensing, management, storage, and retrieval. And standards must still be developed so that third party IP will be compatible with proprietary design blocks. Quality of Service (QoS) priorities are also difficult to establish when industry standards are constantly changing.

Along with Steve Wilton and Andre Ivanov, Saleh is working to develop programmable IP blocks with on-chip testing capability, and Computer Science colleague Alan Hu is investigating issues of high-level verification of SoC design. *continued on back page*

Cutting Through Contradiction in New Software Models

Tim Menzies uses AI tools to find key testing variables in the complex chaos of software code.

The concept of using randomized search for software testing still raises indignation—and eyebrows—among many software engineers, who prefer to use established methods to ensure that software products are reliable and predictable. However, they face an increasingly daunting challenge. As software requirements increase, so does complexity, and testing involves solving extremely difficult NP-hard problems (computationally intractable problems for which there are no known efficient algorithms) or trying to find the best possible solution within a web of variables and possibilities. In the dog-eat-dog dot.com world, software developers simply don't have the time or money for traditional testing.



Studying ants to understand software

"Pragmatically, we know that 60 to 80 percent of the requirements of any system appears after the first version of software has been fielded," says cognitive scientist Tim Menzies. "Whatever picture you have at the start is at best 20 to 40 percent correct." Menzies explores how quirks in human cognition affect the process of software and knowledge engineering. Of all the variables in software design, the greatest are human factors such as having different designers with their own approaches and concerns working on the same product. "Yet somehow, reasonably good software is produced most of the time," he says.

He and Computer Science colleague Holger Hoos are part of a group of researchers who are studying the self-organizing behaviour of ant colonies to try and unravel the shape of software and the mystery of why, as a rule, it works so well. "If we try to describe software as pathways, are they expressways or tangled spaghetti?" Menzies asks. The answer seems to be a bit of both, and the emergent behaviour of ants provides a clue to the inherent order in software's randomness. Consider the apparent chaos of an ant colony. When forager ants search for food they lay down a trail of pheromones. The other ants follow the scent of the forager that returns first, and this becomes the expressway to the food source.

Now, imagine software as ants running in a maze, or trying to get from the head to the feet of a skeleton. There are things the ants don't know about the space they are exploring, and they have differences of opinion as to the best way to get from point A to point B. Should they go down one arm, or another, or down the spine? Eventually, they will choose the spine. Menzies is interested in settling these "arguments" in software design by helping developers sift through redundant options to find the pathway of least resistance. His "funnel theory" shows how this narrow "software backbone" contains variables that appear in every solution, producing an expressway out of the spaghetti of code. Simple machine learners can explore software with funnels to automatically find order within the apparent chaos.

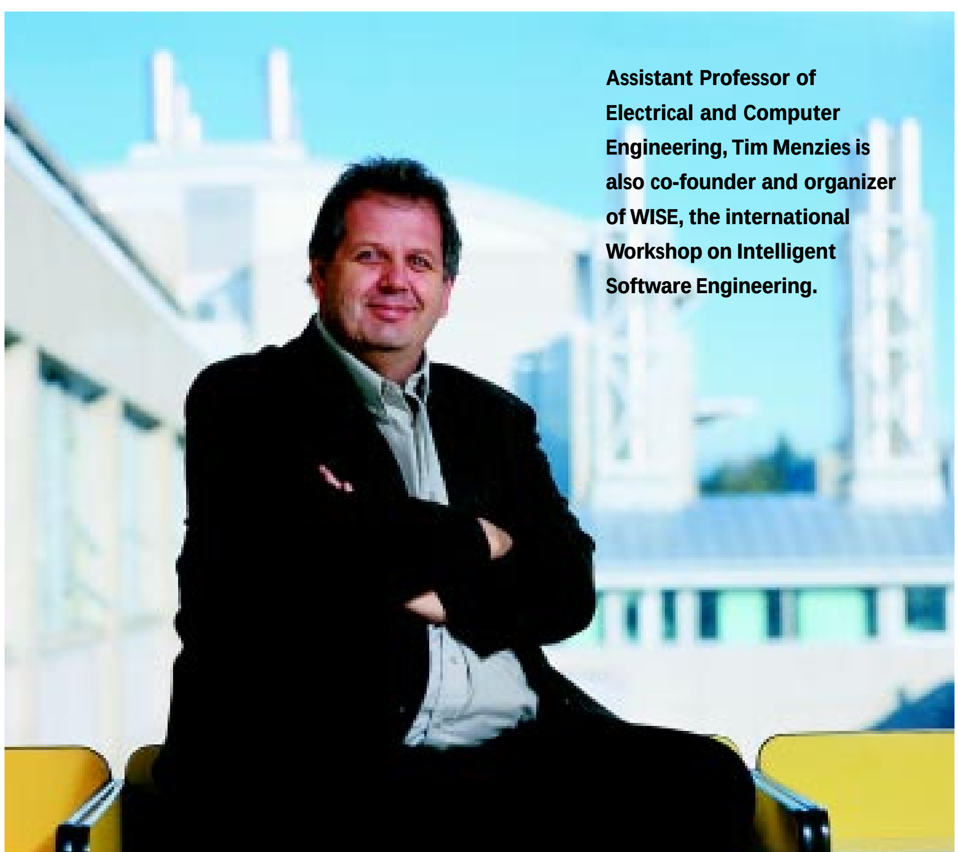
Tarzan: finding pathways in a jungle of code

"The surprising observation is that if you troll the space of possibilities, you will usually find a small number of master variables that control the rest of the show," says Menzies. He is currently working with Marcus Feather and NASA's Jet Propulsion Lab on requirement engineering for deep space missions. Flight software has to be highly reliable and there are always early life-cycle decisions where people disagree.

Menzies' early life-cycle assessment tool, called Tarzan, can sift through millions of combinations to determine which ones offer the most direct pathway to the best solution. He notes that Tarzan's ability "to swing through decision trees" has many other software applications.

Menzies believes that most software code inherently generates these expressways. "If you think about how complex the universe is, and how many options we face each day and how we manage to muddle on through, either we have some wonderful control over the universe, or there is more order in its randomness than we thought. My money is on the universe."

Tim Menzies can be reached at timm@ece.ubc.ca or at (604) 822-3381



Assistant Professor of Electrical and Computer Engineering, Tim Menzies is also co-founder and organizer of WISE, the international Workshop on Intelligent Software Engineering.

Orchestrating the Harmony of Bits

Holger Hoos designs and analyzes algorithms for an eclectic range of areas, from artificial intelligence and computational musicology to bioinformatics.

Bassoonist and Assistant Professor of Computer Science, Holger Hoos is also co-organizer of the IJCAI Workshops on Stochastic Search Algorithms and Empirical Methods in Artificial Intelligence.

Computer scientist, musician, theorist, scuba diver—Holger Hoos is truly a man of the post-modern renaissance. His ability to thrive in both research and creative environments has led to a unique cross-pollination of research interests. A bassoonist who played regularly with several ensembles in Germany before coming to UBC, Hoos admits that music has influenced much of his research. "The department here is fantastic. I think ICICS will provide great opportunities for me to tie all of these interests together," he says.

Hard problems & stochastic search

Hoos' initial research was on the satisfiability problem (SAT), a prototypical hard (NP-complete) combinatorial problem, which involves a number of logical variables connected with "and" and "or." SAT plays a central role in three key areas of computer science: theory and computational complexity, artificial intelligence and automated reasoning, and hardware design and verification. As software systems and their underlying algorithms become more complex, rigorous theoretical analysis is increasingly difficult. Although it is possible to see and analyze each line of code, it is often next to impossible to predict the global behaviour of algorithms, and this is critical in being able to apply or improve software systems.

Along with Electrical and Computer Engineering colleague Tim Menzies, Hoos is a pioneer in the emergent field of empirical computer science. "Tim and I tend to view certain algorithms and systems as physical or biological phenomena, where you don't really know, or care, what happens at the most detailed level. Yet you can observe, hypothesize and model the system's behaviour, and then test it through further experiments," he says. For example, stochastic search algorithms use randomized decisions that can actually increase the efficiency of the search. However, the resulting behaviour is very complex and can often only be analyzed empirically. He and Menzies draw on biological models such as Ant Colony Optimization to try to build a theory on how stochastic search techniques can solve NP-hard problems faster and more efficiently.

Hoos' interest in biology dates back to his undergrad studies at TU Darmstadt in Germany. Along with Computer Science colleagues Anne Condon, Nick Pippenger and David Kirkpatrick, Hoos recently founded the Bioinformatic, Empirical and Theoretical Algorithms Laboratory (ß-Lab) at UBC. Bioinformatics is a new field of study that combines research in molecular biology, computer databases and algorithms in order to facilitate biological research, particularly in the field of genomics. Hoos, Condon and ß-Lab colleagues are working on projects such as inverse RNA folding, DNA word design, and phylogenetic analysis for environmental ecology applications.

Computational musicology

Hoos' work in computational musicology involves collaborations with colleagues across campus, including Keith Hamel from the School of Music. Hoos developed the GUIDO Music Notation Format to represent music (and the parameters of duration, tone, pitch, and instrumentation) at a logical level in an electronic, humanly-readable form. The motivation for GUIDO came from his early work on SALIERI, a software environment that supports the computer-assisted composition, manipulation and analysis of music. In addition to being able to quickly transpose, edit, listen to music, and see the score, the user/composer can create computer music from mathematical concepts or even biological sequences. "One exciting example is you can render DNA sequences musically, and this can complement our visual perception of this kind of data in a most enthralling way."

Does Hoos still find time to play bassoon? "I really miss playing, but bassoonists are pretty rare so I'm confident that I will find an ensemble to play with," he says. "The only thing that's not ideal about my situation here is I am involved in too many interesting things."

Holger Hoos can be reached at hoos@cs.ubc.ca or at (604) 822-1964

Capturing our Attention

To Ron Rensink, seeing is not necessarily perceiving. He is one of several new CICSR members whose study of human experience is key to ICICS.

How does a magician mesmerize? What processes are or aren't at work that allow us to be convinced by "now you see it, now you don't" sleight of hand? Why do we sometimes simply not see things that are right in front of us—like a car bumper, for instance? An assistant professor in Computer Science and Psychology, Ron Rensink's work in attentive and pre-attentive processes is unravelling some of the riddles of perception and consciousness.

Rensink came to this field of study by a rather circuitous route. After completing his master's degree in theoretical physics at ubc he went on to study ai and computer vision. "I was inspired by Bob Woodham to talk to researchers who study real vision," says Rensink. He began working with Anne Treisman and later Jim Enns in the Department of Psychology and this led to a postdoc at Harvard's Vision Sciences Lab. Rensink's work in computational studies and psychophysics led him to discover that the processes involved in human sight—such as interpreting three-dimensional curvature, depth and surface properties—are much more complex than originally thought.

Looking without seeing

From Harvard, Rensink went to work for Cambridge Basic Research (CBR), a collaboration between MIT, Harvard and Nissan. There he studied the issue of invisibility, or why so many drivers involved in traffic accidents claim not to have seen what was right in front of them. At first it was thought the phenomenon was caused by poor visibility. "It turns out it is attentional," says Rensink. "You actually have to focus your attention on the thing that is changing in order to see it, otherwise you will effectively be blind to the change no matter how large it may be."

That means if a driver in front of you puts on the brakes, and you are changing a CD, or talking on a cell phone (as a recent ICBC study has confirmed), you probably won't notice until you actually focus your attention on the brake lights. And with cars becoming

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***ICICS** continued from page 1*

unique interdisciplinary research institutes in the world, and bring together researchers from the faculties of Applied Science, Arts, Commerce, Dentistry, Education, Forestry, Medicine, Pharmacy, and Science.

The new ICICS facility is scheduled for completion in the 2002-2003 academic year. Its space and equipment will support research that consists of three overlapping components: human communications technologies, multi-agent systems and global information systems. The largest infrastructure component will be a fully-equipped human communications technology laboratory that will include a human observation and measurement lab, a virtual reality room and a fully instrumented system demonstration lab. A robust, high bandwidth intra- and inter-building communication network—complete with manipulators and robots—will explore multi-agent technology. A parallel router/switching facility will support research in global information systems.

The research undertaken at ICICS will have applications in e-commerce, education, engineering, entertainment, linguistics, medicine, and psychology. "The breadth of disciplines that are represented is quite unique," says Srivastava. For example, the large amount of funding available for IT research in the US means that most of their academic institutions tend to specialize in certain areas. ICICS's founders all agree that improving human-computer interaction begins with improving interaction between people—and this means bringing researchers together under one well-equipped roof.

ICICS infrastructure

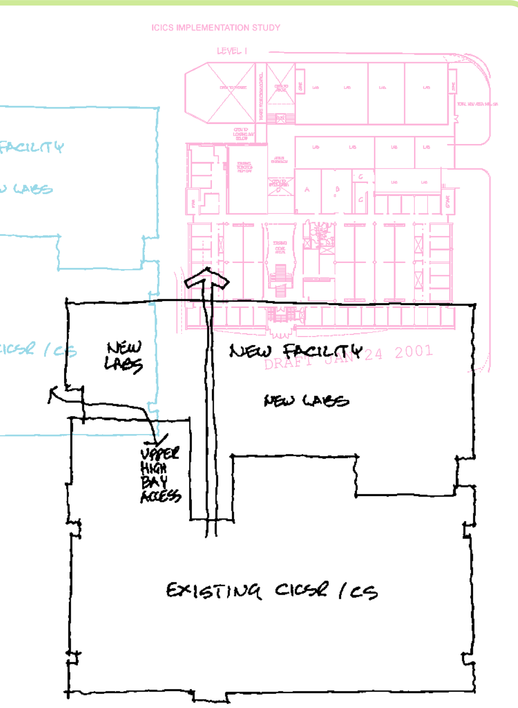
The new 30,000 sq. ft. ICICS facility will include

- 4 Onyx II Infinite Reality Systems for real-time image generation
- Optotrak for high-speed tracking in the Human Measurement Studio
- Electromagnetic Articulograph (EMA) for tracking the human face and tongue
- 6 degrees-of-freedom tracking devices, body suits, cyberglove and stereo head-mounted displays for virtual reality and interactive visualization projects
- Staubli AX170 Unimation and CRS A465 Ind. Robotic robots for intelligent multi-agent systems research
- 2 fully wired and switchable large video projection rooms with high-quality audio
- Research infrastructure for file services, online A/V services, backups, and multimedia production

"We want to change the focus of our research so that human needs come first,"

Sid Fels: "I think an artist goes through a similar process as an engineer in that both are involved with bringing an idea into existence—into something you can see, hear, use, or appreciate."

◄ Computer Scientist and Psychophysicist Ron Rensink is helping to design simpler, more effective interfaces for increasingly complex tasks.



" says CICSR director Rabab Ward.

Embracing Embodiment

"Technology is driving a way of thinking that was not possible before," says Sid Fels. "And this is changing how we define ourselves and our tools."

Electrical and computer engineer and media performance artist, Sid Fels spends a lot of time thinking about the nature of technology and our relationship with it. One of the ten principal researchers on the ICICS proposal, Fels explores issues of embodiment and human-computer interaction.

Forklift Ballet

Fels' multimedia dance collaboration, Forklift Ballet, was recently performed in Acqui Terme, Italy. In the piece, skilled drivers guide electrical forklifts about the stage in a semi-choreographed "ballet." An accompanying musician performs synthesized music by moving two wands through space. The ballet examines the way that people embody technology. To drive a forklift with proficiency and precision involves an intimate relationship between human and machine, where the machine becomes an extension of the body and its use involves both physical skill and expression. In contrast, the musical wands are difficult to embody, and the music they produce seems somewhat devoid of expression beside the graceful movements of the machines.

"The reason is that forklifts—and conventional musical instruments—give you force-feedback, so they really do become part of your body," says Fels. He believes that human aesthetic, physical and emotional needs must be integrated into engineering and design in order to develop more adaptive, intuitive and satisfying interfaces.

Modelling human speech

Fels has already created a system that supports embodiment—Glove Talk II—which allows users to talk with their hands (see *Focus* Spring 1999). He and other ICICS researchers, including Bryan Gick (PSYC) , Dinesh Pai (CS) and Kathy Pichora-Fuller (AUDI), are working on articulatory speech synthesis, which involves modelling human speech to produce more natural-sounding synthesized speech.

"Think of your vocal tract as an irregularly shaped tube, with a tongue and uvula and fleshy walls of muscle," says Fels. "Current 2d models condense those shapes into simple circular cross-sectional areas." To understand and model how our vocal tract really works first involves collecting data from imaging tools such as x-rays, MRI, ultrasound, and magnetic tracking of the tongue. Airflow is then simulated through the vocal tract and articulatory phonetics is used to determine how movements of the tongue, uvula, cheeks, and lips change the shape of the vocal tract to make different kinds of sound.

Would an automated message be less annoying if the voice sounded sincere? Would the voice of an AI tutor be more captivating if it sounded more human? Possibly. Certainly avatars such as Britain's Anna Nova or the late Max Headroom would be more life-like. Since articulatory speech synthesis connects the face and vocal tract models, the facial movements would be perfectly synchronized with speech.

"We know this is a major contributor to the understanding of speech," says Fels. "We believe that these articulation patterns will be much easier for voice recognition systems to use." And if it is easier for computers to understand us, it will be easier to design better voice-based interfaces.

Changing human-computer relationships

Whether developing AI applications or creating new media performances, Fels

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Going Against the Flow

Ian Frigaard models complex flow problems in non-Newtonian fluids for industry partners.

When we squeeze a tube of toothpaste, dollop whipped cream on a latté, or put gel in our hair, we likely don't think of these substances as "fluids" or consider the complex properties that make them behave the way they do. Most fluids are Newtonian, with predictable behaviour and viscosity (or resistance to flow when subjected to stress). Non-Newtonian fluids (such as pastes and gels) display such a complicated array of properties that their errant behaviour still eludes theorists. It is this very complexity that fascinates new CICSR member Ian Frigaard.

"I am motivated by physically complex engineering problems in which analysis requires a mix of different mathematical methods." Frigaard's concurrent academic/industry experience played a crucial part in directing his research. He completed his PhD at Oxford while working for Alcan, and as a postdoctoral student at Cambridge he worked as an oil and gas research engineer with Schlumberger. Both positions involved the study of non-Newtonian fluids.

"Schlumberger is one of the few global industrial companies with a dedicated research facility for fluid mechanics," says Frigaard. As a rule, companies tend to contract out this type of research, which is often conducted with university partners. He says the challenge is for academic researchers to understand what companies want, and for industry to realize that solutions to complex engineering problems require basic research.

Solving "mud problems"

One example is drilling for oil. Rotary drilling involves controlling the complex interaction between two non-Newtonian fluids: drilling mud and cement. Drilling mud is a weighted fluid that is circulated into the well bore through the drill pipe. The mud's hydrostatic pressure prevents water and gas from seeping into the well and causing blowouts or "gushers." It also carries rock cuttings to the surface and lubricates and cools the drill bit. However, wells usually deliver oil, gas and water in continually changing proportions, and developing treatment fluids with the right viscosity and weight to maintain the desired pressure depends on continuously changing variables. Modelling this complex flow behaviour is critical to developing the right drilling mud for the job.

In deep drilling, a series of progressively smaller steel casings are inserted into the well and cemented to the outer circumference of the borehole to prevent the transfer of fluids into the well. This method allows wells to be drilled to depths of more than 9,000 meters through rock formations that have fluid pressures greater than 1,400 kilograms per square centimetre. The difficulty is getting the cement down into the well, which means displacing one non-Newtonian fluid with another. "The deeper you go, the less flexibility you have on how fast you can pump fluids," says Frigaard. "As the well becomes narrower and more complex, its changing geometry alters the fluid behaviour." The very characteristics of the mud, the density and weight required for drilling, make this displacement extremely difficult.

"I am motivated by physically complex engineering problems in which analysis requires a mix of different mathematical methods."

Frigaard is currently working with two UBC grad students to help Schlumberger solve these "mud problems."

Capping oil wells

A major concern for Canadian oil companies is pressure and leakage at the surface of capped wells. To stop surface casing vent flows, companies must first determine the depth of the leakage, make a hole in the casing and then inject it with cement. In addition, a series of cement plugs must be inserted at various depths of the well to seal the casing hole. Since cement is heavier than the fluid beneath it, the properties of the mud must be such that the cement remains suspended on top and dries and seals without falling down the well. Frigaard's research is helping companies like Schlumberger avoid the extensive cost of repairing leaks by ensuring that their wells are environmentally sound at the outset.

"The challenge is not necessarily in the mathematics, but in its application to complex problems, and this involves understanding the dynamics of the systems involved," says Frigaard. "With the Pacific Institute of Mathematical Sciences (PIMS) and the Institute of Applied Mathematics (IAM), UBC is one of the strongest places in North America to pursue this kind of work."

Ian Frigaard is at (604) 822-1316 and frigaard@mech.ubc.ca

Point Grey's Computer Visionaries

UBC spin-off Point Grey Research is trailblazing computer vision technology for a host of emerging and yet-to-be-envisioned applications.

Imagine a computer that recognizes your face, greets you in the morning, and logs in all of your passwords automatically. Imagine being able to search databases of 3d images that you can rotate with simple hand and face gestures. Or, imagine machines that perform complex tasks in hostile environments, such as underground mining and arctic mapping, without the need for human intervention. Computer vision is the core technology on which much artificial intelligence (AI) research and application depends.

In four short years, Vancouver's Point Grey Research (PGR) has become a leading developer of computer vision hardware and software for an expanding array of applications. The company was founded in 1997 by former CICSR MSc students Vladimir Tucakov and Malcolm Steenburgh; Don Murray, currently a PhD student at ubc; and Rod Barman and Stewart Kingdon, former technical staff of the Institute for Robotic and Intelligent Systems (IRIS). "Much of the research leading up to PGR's spin-off was funded by IRIS's Technology-GAP program," says Tucakov.

Digiclops and Triclops

The core of PGR's computer vision hardware is Digiclops, a digital stereo vision camera that captures 3d imagery in real time and on-line for applications such as object and people tracking, virtual reality modelling language (VRML), human-machine interfacing, and mobile robotics. The Digiclops camera is an extremely sophisticated sensor with a large field of view. Unlike laser sensors, which scan an object by beaming light at it, the Digiclops is passive, instantaneous, and operates in dynamic and unstructured environments. Three cameras are used to capture 3d information, so high calibration is the keystone of the Digiclops system. All images are synchronized internally, producing accurate and dense 3d measurements of both horizontal and vertical features. Triclops is the complementary software development kit that enables accurate, high-speed 3d processing of digital stereo images. When the products were launched in December 1999, the demand was so great that the company sold out the first production run before the first unit was even completed.

The company is working with high-profile players such as Microsoft, Intel, Hewlett-Packard, MIT, and NASA on several high-cost, low-volume applications. For example, Microsoft uses PGR's Digiclops camera in the development of smart homes and intelligent environments. While working with these companies enhances PGR's credibility in the marketplace, Tucakov believes the real growth potential lies in high-volume, low-cost applications. "We can customize the core technology to a wide range of applications," he says. "The challenge now is to find strategic partners and identify their needs."

Emerging markets and applications

Point Grey Research is currently developing applications in the retail, safety and security industries. The company's Censys3d software can recognize and track individuals in a crowd under varying lighting and environmental conditions. People tracking is used in retail environments to improve

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Point Grey Research: (from left to right) Don Murray, Malcolm Steenburgh, Rod Barman, Vladimir Tucakov, and (front) Stewart Kingdon.

The Geometry of Shadows and Light

By studying how light shapes and shades objects in the natural world, Wolfgang Heidrich generates computer images that are more photorealistic.

Have you ever watched a televised weather report and noticed the peculiar way shadows are cast on the set? Or wanted to buy an item on-line, but didn't have enough visual information to make a decision? These are some of the problems that Wolfgang Heidrich is hoping to remedy. A new CICSR member and assistant professor in Computer Science, Heidrich came to UBC from the Max Planck Institute for Computer Science in Germany, where he was working on interactive computer graphics for use in industrial design.

Photorealistic rendering in industrial design

One of Heidrich's projects in Germany was the simulation of car interiors with BMW. The traditional process for most industrial design applications has been to build several physical prototypes. While computer modelling and simulation is now changing this process, the problem with traditional computer graphics is that the images tend to be so pared down that they no longer have any physical meaning. "It looks moderately okay, but you have no way of making anything that follows physical laws and corresponds to something that exists in the real world," Heidrich says. While interactive computer graphics can simulate materials in an immersive (virtual reality) environment, they still require more refinement before industrial designers can use them to make meaningful decisions.

Global illumination

Typical problems with current rendering methods involve how light interacts with the surface of objects. Simple graphic renderings use local illumination, which model a single light source interacting with an object's surface. But most light sources are not direct, and light bouncing off walls and other surfaces affects how we perceive shadows, colour, texture, and depth. Global illumination takes all of this light activity into account. This is particularly important in photorealistic rendering and in applications such as lighting design—for example, where you put a light source in a car console. "If you are driving at night, and wearing a white shirt, you don't want a light source that shines onto your arm, because you will not be able to see anything outside," says Heidrich.

Image-based rendering and microgeometry

Image-based rendering uses calibrated cameras and light sources to capture geometry and measure the appearance of materials so that they can be more easily modelled and graphically rendered. This works well for simple smooth-surfaced objects and materials that are not too shiny. However, photorealistic simulation of complex materials such as fabric and carpet requires not only modelling the geometry of the fibres at a microscopic level, but also modelling the microscopic reflection of light bouncing off each fibre.

Heidrich has some remarkable examples of these techniques. In one simulation of a room, an image of sheer curtains has the effect of silk taffeta, where the warp and weft threads are different colours. The fabric shimmers and changes colour with the angle of the light. In another example, a picture of clouds is illuminated by a single light source. "Here, you only see the light that comes off the clouds directly. But when you also simulate how the light bounces around between the different water particles within the cloud, you get a much more realistic picture," Heidrich says. Indeed, the effect is startling. He and colleagues have developed a global illumination algorithm to enable more efficient and faster modelling of microgeometry and global illumination effects.

Applications for interactive computer graphics include virtual and augmented reality, e-shopping catalogues, computer games, and special effects for the movie industry. "With the research expertise at UBC, and companies like Electronic Arts, Radical Entertainment, and MainFrame here in Vancouver, this is definitely one of the best places for me to pursue my work," says Heidrich.

Wolfgang Heidrich can be reached at heidrich@cs.ubc.ca or at (604) 822-4326

CICSR Passing Notes

In the last issue of *Focus* we promised a profile of **Rob Rohling** (ECE). Rob arrived only in January, so we had to postpone his story. **Kris de Volder** (CS)and **Will Evans** (CS) also joined us in January so watch for profiles of these new CICSR members in the future.

Vinod Modi (ME) received the Control Authority Award for his entry entitled "The Moving Surface Boundary-Layer Control," at the Fluids 2000 conference of the American Institute of Aeronautics and Astronautics.

Nick Jaeger (ECE) has received the NSERC University-Industry Syngery R&D Partnership Award, in conjunction with **Farnoosh Rahmatian** of Nxtphase Corporation, **Brent Sauder** of BC Advanced Systems Institute (ASI), **Greg Polovick** of BC Hydro, and **Vern Buchholz** of Powertech Labs. The award recognizes the collaboration that led to the transfer of photonics technology from Nick's lab to the power measurement marketplace.

David Pulfrey (ECE), a new CICSR member, has been elected a Fellow of IEEE "for contributions to the modelling of hetero-junction bipolar semiconductor devices." (More on David in a future issue.)

Recent winners of ASI Research Fellowship grants include **Cristina Conati** (CS), **Ian Frigaard** (ME), **Wolfgang Heidrich** (CS), and **Robert Rohling** (ECE). **Victor Leung**, **Babak Hamidzadeh** and **Matt Yedlin** (all of ECE), in partnership with Telus, have received funding from the ASI Strategic Research Program.

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smarter and dashboards more like cockpit controls, drivers have much more to pay attention to. Nissan is looking at possible applications of Rensink's research on attention processes in brake light design. They found that having lights flash on two or three times, instead of only once, produces far better detection of brake light onsets than standard brake light systems. "Many problems that are interesting from an academic perspective are also of great interest to industry," says Rensink. "This is just one example." He is also working on applications in computer vision and human-computer interfaces.

Controlling the chaos of free flight

If today's drivers are overwhelmed with information, imagine how air traffic controllers must feel. "With so many people flying, the density and capacity of traffic control systems is stretched to the maximum," says Rensink. As a result, the current "highways in the sky" system will eventually change to free flight, where flight patterns will be more random and controllers will have to do more manual tracking. Obviously, this involves a greater risk of human error. Rensink is working with Kelly Booth, Karon MacLean and Brian Fisher from Computer Science, and Jim Enns from Psychology, to develop new displays for air traffic control systems.

"If we know what kinds of errors humans make, we can design our systems to compensate for them." Rensink notes that our attentional processes account for only part of what we are actually aware of, therefore our brains are able to process much greater amounts of information than we realize. He wants to replace some of the conscious "thinking" processes, such as having to interpret coded instrumentation, with "intuitive," non-attentional processes of other sensory systems, such as simple visual and auditory recognition. The trick is understanding—and learning how to trust—these more intuitive processes. "We need to download some of the conscious work and let our unconscious mind do the walking," says Rensink.

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Dr. Alain Fournier
(1943-2000)

Alain, a CICSR member and professor in the Department of Computer Science, passed away on August 14, 2000. He is fondly remembered by his colleagues, his students, his family and his many friends.

An endowment fund has been established to honour Alain and his contributions to the field of computer graphics. The endowment will fund a scholarship to a PhD student in computer graphics at a Canadian university.

Alain's influence as a scientist, a teacher, a mentor and a friend went far beyond the boundaries of UBC. He is remembered with respect, gratitude and abiding affection. The scope of his research profoundly affected the field of computer graphics at many levels. It is therefore fitting that the scholarship should be national in character, and that it should be adjudicated by Alain's former doctoral students, in conjunction with the Department of Computer Science at UBC.

We invite friends, colleagues, alumnae—indeed, anyone who felt Alain's influence—to contribute to the Alain Fournier Scholarship. It is our hope and expectation that Alain's memory will live on for generations to come through this endowment. Please send your contributions to

The Alain Fournier Memorial Fund

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University of British Columbia
201-2366 Main Mall,
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canada

***Saleh** continued from page 3*

"I believe the greatest challenges also present the greatest research opportunities," says Saleh. He notes Canada has taken a very strategic view of SoC. The Canadian Microelectronics Corporation (CMC) has been funded to the level of $40 million to build the infrastructure, acquire the intellectual property and install the management facilities to allow Canadian researchers to access IP through a virtual private network.

This was a large part of Saleh's motivation to move back to academia from industry positions at Simplex, Nortel, Tektronix, Toshiba, and Mitel. He chose Canada because of the CMC infrastructure and the high quality of expertise at UBC. He also credits industry partner PMC-Sierra for major funding and support. He believes all of the ingredients are in place to create a research centre of excellence in SoC/IP. "We have innovative experts in the field, high-visibility projects, state-of-the-art equipment, lots of funding from industry and government, and the ability to attract key researchers."

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shopper-to-cashier ratios, labour scheduling and product placement. It also helps with merchandising decisions by monitoring how many shoppers stop at product displays and for how long. For security and safety systems, the advantage of this technology over video monitoring is that someone doesn't have to continuously watch a screen in order to identify suspicious behaviour, unauthorized individuals, or personnel entering hazardous areas. The camera's 3d sensors are not affected by shadows or sunlight and can accurately pick individuals out of a crowd. PGR is also researching applications in virtual reality, computer interfaces, interactive entertainment, medicine, manufacturing, and the automotive industry.

"We can customize the core technology to a wide range of applications. The challenge now is to find strategic partners and identify their needs."

"What we are really undertaking is a technology push, which is very difficult because the applications are still emerging," says Tucakov. But he is confident that once companies understand what PGR's products can do, the applications will follow. "As technology becomes more affordable, computer vision applications will become more commonplace."

For further information on Point Grey Research, contact Vladimir Tucakov at tucakov@ptgrey.com

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doesn't distinguish between the practical and artistic applications of his work. He credits Japan's Advanced Telecommunications Research Laboratories (ATR) for much of his funding.

"If someone creates a new technology for bungee jumping, it is really no different than if I create some weird interface for making music," he says. And whether for aesthetic enjoyment, thrill seeking or increased productivity, the beauty and merits of any technology—like art—rest with the viewer/user.

"ICICS will provide an opportunity for scientists, engineers and artists to work together to change the way we think about and design technology—not merely as something that gets a job done, but as something from which we get pleasure and satisfaction."

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

The UBC Centre for Integrated Computer Systems Research (CICSR) is an interdepartmental research organization made up of computer-related research faculty members in the departments of Computer Science, Electrical and Computer Engineering, and Mechanical Engineering. Currently, there are more than 80 CICSR faculty members who direct over 350 graduate students and collaborate with dozens of industrial firms in areas such as robotics, artificial intelligence, communications, VLSI design, multimedia, and industrial automation.

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