Communications Research Centre Canada
An Agency of Industry Canada
Centre de recherches sur les communications Canada
Un organisme d'Industrie Canada

Research Activities by Canadian Universities

Information and Communication Technologies

CRC

Business Development Office

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RESEARCH ACTIVITIES by CANADIAN UNIVERSITIES

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Canada

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Forward

One of the mandates of CRC and other government department laboratories is to improve technological innovation and to enable the diffusion and application of new technology to Canadians.

Developing national collaboration with appropriate universities in Canada facilitates university researchers in national projects to develop next-generation ICT technologies. The next generation of advanced technologies will be expensive to produce, and no one entity has the capability and expertise needed. Co-operative development to share costs, risks, expertise and benefits is the new paradigm.

One of the objectives in highlighting the work being undertaken by Canadian universities in the communications sector is to enhance the innovative process in Canada by striving to forge partnerships between research groups in Canada especially at the pre-commercialization stage.

The ultimate goal is to give Canadian companies a competitive edge in today's marketplace once the product or process definition is enabled by this partnership between government labs, university researchers and Canadian industry.

The identification of some of the pertinent research being undertaken by Canadian universities in the enabling technology sectors in ICT should provide a baseline of potential collaborative partners and help transform ideas into new ICT technologies that can be transferred to innovative Canadian firms and OGDs.

The compiled list is not considered comprehensive but scopes out some identified activities that are taking place in universities in the broadband, optical components, wireless, electromagnetic, multimedia, broadcast and signal processing niches in the ICT sector.

Although an effort has been made to define current activities and proponents involved, particularly in the Canadian Research Chairs, the currency of the identified research is not readily verifiable as ICT roadmaps and the churn in research personnel are not readily tracked as to their present status.

Don Olcheski, CRC, BDO, October 2, 2008

Photonics, Fibre Optics and Nanotechnology

Electromagnetic Materials and Applications		
Chair in Advanced Materials for Microelectronics and Optoelectronics	École Polytechnique de Montréal	
Chair in Ultra Rapid Photonics Applied to Materials and Systems	Université du Québec	
Canada Research Chair in Materials Micro/Nanoenrineering Using Lasers	École Polytechnique de Montréal	
Research Chair in Advanced Polymer Material	University of Toronto	
Canada Research Chair in Quantum Semiconductors	Université de Sherbrooke	
Chair in Ultrafast Photonics and Nano-optics	University of Alberta	
Research Chair in Computational Nanophotonics	University of Ottawa	
Research Chair in Quantum Computation	University of Waterloo	
Canada Research Chair in Condensed Matter Physics	University of Alberta	
Canada Research Chair in Materials Science	Acadia University	
Chair in Nanostructured Organic and Inorganic Materials	Université du Québec	
Nortel Networks -- Canada Research Chair in Emerging Organic Materials	Carleton University	
Research Chair in Communications and Optical Fibre Components	Université Laval	
National Research Council-Canada Research Chair in Attosecond Photonics	University of Ottawa	
Research Chair in Digital Communications	University of Toronto	

Wireless and Mobile Communications Systems

Electromagnetics, Electonic Components and MEMs

Research Activity	**University**	**Page**
Research Chair in Microwaves Antenna	Royal Military College of Canada	
Research Chair in High-Frequency Electromagnetics	McMaster University	
Research Chair in Applied Electromagnetics	University of Calgary	
Canada Research Chair in Applied Electromagnetics	The University of Manitoba	
Research Chair in Advanced Microelectronic Systems Architecture and Development	École Polytechnique de Montréal	
Research Chair in Microjoining	University of Waterloo	
Research Chair in Microelectronic Materials	The University of Manitoba	
Research Chair in Electronic Materials and Devices	University of Saskatchewan	
Research Chair in Electronic Materials and Devices	University of Saskatchewan	
Canada Research Chair in Electrical Energy Conversion and in Power Electronics	Université du Québec	
Canada Research Chair in Queen's University Power Electronics	Queen's University	
Chair in Powering Information Technologies	McGill University	
Chair in Advanced Micro/Nanofabrication/MEMs	University of British Columbia	

Research Chair in MicroElectroMechanical Systems	McMaster University	
Chair for Automotive Sensors and Sensing Systems	University of Windsor	

Emerging Technologies

Research activity	**University**	**Page**
Canada Research Chair in Information Technology	Concordia University	
Research Chair in Statistical Signal Processing	The University of British Columbia	
Research Chair in Signal Processing Systems	University of Toronto	
Canada Research Chair in Signal Processing	McMaster University	
Research Chair in Communication Algorithms	University of Toronto	
Research Chair in Autonomic Service Architecture	University of Toronto	
Research Chair in Interactive Network Computing and Teleoperation	Carleton University	
Research Chair in Information Theory and Multimedia Data Compression	University of Waterloo	
Canada Research Chair in Internet Video, Audio, and Image Search	University of Toronto	
Research Chair in Human-Centred Interfaces	University of Toronto	
Chair in Distributed and Collaborative Research	Dalhousie University	
Canada Research Chair in Large-Scale Distributed Interactive Simulation Systems and Mobile Computing and Networking	University of Ottawa	
Canada Research Chair in Quantum Information Processing	Université de Montréal	
Research Chair in Computer Graphics and Animation	University of British Columbia	

Canada Research Chair in Information Visualization	University of Calgary	
Research Chair in Combinatorial Optimization	Concordia University	
Canada Research Chair in Information Technology	McMaster University	
Research Chair in Electronic Health Information	University of Ottawa	
Research Chair in Multimedia and Computer Technology	Ryerson University	
Research Chair in Next Generation Groupware	University of Saskatchewan	
Research Chair in eHealth Innovation	University of Toronto	
Research Chair in Tetherless Computing	University of Waterloo	
Research Chair in Information Fusion	McMaster University	
Chair in Stochastic Simulation and Optimization	Université de Montréal	
Chair in Stochastic Simulation and Optimization	Université de Montréal	
Research Chair in Privacy and Security	Dalhousie University	
Canada Research Chair in Algorithm Design	University of Waterloo	
Chair in Information Technology in Health Care	HEC Montréal	
Research Chair in Combinatorial Optimization	McMaster University	
Research Chair in Computational Intelligence	University of Alberta	
Canada Research Chair in Graph Theory	McGill University	
Canada Research Chair in Number Theory	University of Waterloo	
Canada Research Chair in Management Informatics	Dalhousie University	
Chair in Adaptive Information Infrastructures for the e-Society	UNB	

Research Chair in Network and Software Security	Carleton University	
Research Chair in Mobile Multi-Sensor Geomatics Systems	University of Calgary	
Canada Research Chair in Environmental Sciences	University of Saskatchewan	
Chair in Advanced Geomatics Image Processing	UNB	
Canada Research Chair in Cognitive Geomatics	Université Laval	
Research Chair in Experimental Cognitive Science	Université de Montréal	
Research Chair in Communication and Society	Queen's University	
Research Chair in Vision and Behavioural Science	Queen's University	

Canada Research Chair in Advanced Photonic Components

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Research involves

Designing, fabricating, and testing photonic components that have been fabricated by laser light processing of high-performance optical materials. The research will contribute to the competitiveness of the Canadian optics industry by providing new directions for photonic device research with a focus on reliability and manufacturability.

Using Laser Light to Create Optical Components

The optical transport, distribution, and manipulation of information permeate the economic and social fabric of our world. Clearly, the optical industry is here to stay and grow, requiring ever-increasing numbers of highly qualified engineers and scientists in photonics. At the same time, the Canadian optics industrial sector faces worldwide competition that is fiercer than ever, and the next generation of optical devices and processes must be even more efficient, less expensive, and more powerful.

Both glass and plastics are used in the optical industry. Components made of glass have penetrated the markets for optical devices. Highly transparent and very easily matched to optical fibres (also made of glass), they are also inherently very stable and immune to environmental degradation. Organic materials (plastics) are also finding niche applications for certain optical processes and will certainly gain importance in the future.

The research activity of Dr. Jacques Albert, Canada Research Chair in Advanced Photonic Components, is concentrated on the use of laser light to process glass and organic waveguide materials. (Most materials in which light waveguides are fabricated can be permanently modified when subjected to intense laser irradiation.) His goal is to fabricate novel devices for routing and coding optical signals. He and his team are creating complex structures, such as filters and couplers, in basic optical waveguides, which provide greater functionality and market value while preserving low fabrication costs. The devices are being submitted to rigorous environmental testing to ensure their reliability and conformity to international standards.

To fabricate these complex devices, Dr. Albert and a team of researchers have put together a versatile laser processing laboratory, which will become a training ground for experts in photonics and provide Canadian industry with new processes and devices for the next generations of optical systems.

Research Chair in Photonics

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Research involves

Interdisciplinary applied and fundamental research to develop novel fibre optic sensors, components and devices based on emerging materials known as photonic crystal fibres. The new devices and components will improve the speed, bandwidth and performance of photonics applications used in aerospace, civil engineering and the environment.

Improving the Performance of Photonic Devices

Photonics plays a critical role in everyday life. Telecommunications, sensor technology, medicine and spectroscopy, to name a few, all rely on this discovery. The most common photonics effect employed to control light transmissions in the dielectric or semiconductor materials of optical fibres, integrated optical wave-guides and other related devices and systems is known as index guiding. Although once considered state-of-the-art, this effect and the technologies which rely on it are approaching their performance limitations. Visionaries like Dr. Wojtek J. Bock are confident that emerging materials known as photonic crystal fibres (PCFs) offer exciting possibilities to develop innovative applications that far surpass current index guiding capabilities.

Dr. Bock is an international expert in optical sensors, as evidenced by his record of publications, grants and patents. His program is focused on developing and implementing an innovative PCF-based enabling technology to achieve optimum performance from novel components and devices used in photonic sensing, communications and other applications. He will focus primarily on creating new applications that benefit aerospace, civil engineering and the environment.

Initially, he will research, model, manufacture and test new wave-guiding structures with unusual transmission properties that can be used in different sensing and communications applications. He will also conduct theoretical and experimental investigations and develop new measurement technologies to determine how environmental parameters affect the transmission and polarization properties of PCFs. And he will examine how much power is lost when novel PCFs and PCF-based devices are connected to traditional optical fibres, fibre devices and integrated optics devices/systems. The long-term goals are to build opportunities to train highly qualified research personnel; to increase cooperation and the exchange of knowledge among collaborating institutions; and to explore ways to turn research discoveries into unique applications that benefit Canadian industry and society.

Canada Research Chair in Nanoengineered Films

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Research involves

Further development of a new materials process, and study of the application of the material in various devices with potential applications in nanobiotechnology and nanoelectromechanical systems.

Thin Films by GLAD

An innovative process was recently invented for fabricating porous, nanostructured thin films with a geometry and porosity that can be engineered to specific needs. The new process, called Glancing Angle Deposition (GLAD), does not require complex lithographic processing; rather, it utilizes computer-controlled substrate motion in conjunction with glancing incidence flux from physical vapour deposition to precisely tailor the columnar structure in thin films. This exciting process was discovered by Dr. Brett and his team.

These porous nanostructured thin films form a new base materials technology that has potentially broad use across many application areas, such as optics, nanobiotechnology, sensing, and nanoelectromechanical or microelectromechanical systems.

In this one-step deposition process, arrays of isolated sub-micrometre helices, posts or chevrons can be fabricated with control over the geometry of the nanostructure, in a type of inorganic self-assembly of structures.

As Canada Research Chair in Nanoengineered Films, he will further develop this new materials process, dividing the work into various projects. These include periodic nanostrucutures and photonic crystals; nanostructured electrochemical devices; nanoengineered inorganic/liquid crystal devices; nanoelectromechanical systems; nanobiotechnology applications; modelling; sensor devices; and speculative and other research.

To cover such broad application areas, Dr. Brett has already established effective collaborations with leading researchers and organizations, including an industry sponsor (Micralyne). He has also formed a company, ChiralTF Devices Inc., which is the primary vehicle for commercializing of GLAD. The ultimate goal of the research is not simply to license the technology, but also to establish a manufacturing facility in Alberta. This technology could have applications in optical devices for photonic and communications firms, the fuel cell industry, materials for nanosystems devices and for improved sensor devices, and optical systems such as flat panel displays.

Chair in Ultrafast Photonics and Nano-optics

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Research involves

Development and use of ultrafast lasers and nano-probing optical techniques to explore new phenomena, materials, structures and processes. For a wide range of applications, including telecommunications and medicine.

Lighting the Way to the Future

The ability to observe and understand structures and materials at the nano (one-billionth of a metre) level holds enormous potential for the development of applications in a number of fields, including telecommunications, semiconductors, material science and life sciences. By using ultrafast lasers and advanced optical sensing methods, scientists can explore the inner structure of matter.

Dr. Elezzabi's research program seeks to achieve a fundamental understanding of many essential physical processes and phenomena that occur on the femtosecond (a millionth of a billionth of a second) time and nanometer spatial scales. The results of his work have the potential to be used to determine the dynamic structure of proteins in their solid forms with minimal radiation damage, the time-dependent structure of molecules while they undergo chemical reactions, and motion of electrons and atoms in semiconductor quantum devices. The ability to understand processes occurring on femtosecond time scales is pivotal to the development of innovative drug compounds, electronic chips and X-ray imaging microscopes.

The first project will be to develop a compact table-top laser-based technique to generate and accelerate ultrashort electron pulses using femtosecond lasers. The goal is to develop this femtosecond electron pulse technique as an effective tool for examining many fundamental processes in nature, including atomic and molecular motion, electron transfer dynamics and kinetics, ultrafast phase transitions, and generation of femtosecond X-ray sources.

The second phase of this research will explore the dynamics of charge carriers in high speed optoelectronic, semiconductor, and photonic devices.

The third project will explore in the electromagnetic spectrum (Terahertz radiation), with direct applications to many areas from pollution detection to medical imaging. They will be developing novel techniques for generating efficient sources using high power femtosecond laser pulses.

Research Chair in Photonic Network Technology

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Research involves

Applying photonics technology to enhance the bandwidth capabilities of network routers; working with industry to test solutions and turn them into marketable products.
This research will help to increase the speed and efficiency of traffic transmitted over a communications network.

Expanding the Power of Photonics

Today's photonics technology, or optical communications, can capably carry one terabit of traffic over a single optical fibre -- the equivalent of 16 million simultaneous telephone conversations. It is small wonder that photonics has become the implementation technology of choice for links between nodes of a communications network. Industry demand for this technology is growing at a tremendous rate. In order to keep pace, researchers are now concentrating on creating innovative petabit (1000 terabit/second) solutions, and on building new switches and network architectures that can extend photonic technology from the core to the edge of a network.

Through a career spanning both industry and academics, Dr. Hall has gained international recognition as an expert in optical, optoelectronic and neural computing. His patented discoveries have greatly advanced the optical communications industry in Europe.

Dr. Hall will be developing new photonics technology to increase the capacity of routers, which are often the cause of severe traffic bottlenecks in a photonics network. His key objectives include developing critical component and potentially disruptive technologies, devising new router and network architectures and control algorithms based on the latest photonics technology, building switch hardware demonstrators to test these architectures and algorithms with real traffic, investigating the self-similar structure of networks to understand how the various levels of hierarchy interact, creating realistic traffic models, and contributing to the development of a self-managed network that offers a defined quality of service.

Dr. Hall will collaborate with leading researchers at the Centre for Research in Photonics who share his interests. Together, their discoveries will help to increase economic growth in the form of spin-off companies and other types of technology transfer, and enhance the competitiveness of Canada's telecommunications and electronics industries.

Chair on Optics in Information and Communication
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Research involves

Studying optics as a powerful tool for information and communication technologies and facilitating fast, reliable, flexible, secure and cost-effective information interchange.

Combining Speed and Mobility in Communications

The success achieved by today's information society is supported by two core features of modern communication infrastructure: mobility and bandwidth. It is through these two features that it is possible to exploit fibre-optic communication and wireless communication.

On the one hand, wireless communication offers mobility; on the other, fibre-optic telecommunication systems provide the massive bandwidth required to handle the heavy traffic on the Internet. Fortunately, although they are independent of one another, these are complementary, convergent technologies. The result is a hybrid wireless-fibre system.

This is the thrust of Hamam's research. His goal is to develop the tools needed to successfully combine the two technologies and thus facilitate fast (high-speed), reliable (low probability of error), flexible (able to ensure mobility), secure (no intrusion) and cost-effective (incorporating inexpensive hardware and software) information interchange.

Chair in Photonic Nanostructures and Integrated Devices

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Research involves

Using nanotechnology to harness and use light in ways never before possible.
Being able to use light in such precise ways will allow us to make major breakthroughs in renewable energy and improve medical diagnosis and treatment, while also having an impact on information storage, sensing, communications and entertainment.

Photonics: Big Results From Thinking Small

As Canada Research Chair in Photonic Nanostructures and Integrated Devices, Dr. Karin Hinzer is working to make that dream a reality. But to reach this big goal, she has to think small—really small. Just as the true power of electricity was not realized until it led us to the world of microchips, the power of light may not be fully realized until we can use it at an almost unimaginably small level.

Working with nanostructures, including quantum dots and photonic crystals—each only a few times larger than a single atom—Hinzer will work to let us fine-tune the characteristics of light in ways never before possible, allowing it to be applied to a broader range of exact and tricky challenges. Hinzer will also work to integrate these functions with others and to develop compact photonic devices that function as optimized optical amplifiers, lenses, solar cells and isolators.

This research will deliver benefits to Canadians by helping realize the true powers of light and apply those new powers to everything from non-invasive medical diagnosis and treatment to communications and information security. Her work also has many applications in both the renewable and traditional energy sectors, and could help establish Canada as a leader in a field.

Chair in Optical Systems for Communications, Imaging and Sensing

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Research involves

Connecting emerging optical technologies to new applications in optical systems leading to novel applications of emerging optical technologies for telecommunications, imaging and sensing systems.

Optical Systems for Communications, Imaging and Sensing Applications

Extraordinary innovation in optical technology has enabled dramatic advances in optical systems such as optical communications systems, storage systems, imaging systems and sensors. Driven by the growth of the Internet, these advances have transformed long-haul bandwidth from a precious resource into a low-cost commodity.

Despite great progress in core and metro networks, however, optical technology has yet to reach last-mile access networks. Although the cable industry and local exchange carriers have developed sophisticated fibre networks, performance limitations of the metallic access connection will at some point force major reconstruction with optical access systems.

He has provided fundamental contributions to the basic understanding and applications in the field of signal multiplexing in lightwave systems, and recognized the opportunity for merging RF techniques with optical transmission and multiplexing. His work formed the basis on which modern cable television systems are built, and transformed the cable-television industry.

With the Canada Research Chair, Dr. Darcie will focus on the novel application of emerging optical technologies for telecommunications, imaging and sensing systems. He will explore applications with three primary classes of enabling optical technologies, optical integrated circuits (OICs), optical fibre transmission technologies, and addressable pixel arrays (APAs). Each of these technologies has advanced dramatically over the past several years, creating potential for novel applications. Dr. Darcie will also conduct research in the area of power control in optical networks, optical layer intrusion protection/detection and broadband last-mile networks.

Dr. Darcie's work will complement existing strong research activities in telecommunications at the university, including wireless communications and microwave engineering, and will lead to collaborations with industry partners in Canada and the U.S.

Canada Research Chair in Nanotechnology

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Research involves

Synthesizing and studying new types of nanometre-scale materials.
Developing new base materials and methodologies for a broad range of emerging technologies and devices in areas such as electronics and biotechnology.

Nanoscale Innovation

At the atomic level, we can begin to distinguish the properties associated with everyday materials such as colour, density, texture, as exemplified by the elements in the periodic table. The different interactions among atoms lead to the wide diversity found in nature, from individual molecules to complex organisms. These phenomena provide the ultimate playground for creating new materials and are at the core of the emerging field of nanotechnology. As we deal with systems whose elementary dimensions are in the nanoscale (one-billionth of a metre), we are learning to tailor materials at the finest level and engineer processes with unprecedented precision.

This research involves establishing techniques for the controlled synthesis of nanostructures, techniques which can then be studied to understand the science at the nanoscale and develop new fields of applications.

Over the next 10 to 15 years, nanotechnology is expected to become a multi-trillion dollar industry. A few examples of the extraordinary range of benefits that it will offer include even greater miniaturization of electronic devices for next generation information technology, clean and abundant energy sources including efficient hydrogen fuel cells, cures for diseases, such as cancer, via cell-specific targeting and treatment, and materials that can be tailored to artificial bone and muscle, as well as many other needs

Research Chair in Nonlinear Photonics

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Research involves

Studying ways of using "non-spreading" optical waves (the so-called optical solutions) to design ultra fast, broad-band optical communications systems and all-optical networks.
The research has the potential to significantly speed up Internet service, and facilitate the development of all-optical computers.

Making the Internet Even Faster

Anyone who has switched from a "dial-up" to a "broad-band" Internet service can appreciate the enormous speed-up of the connection. In the quest for even faster communications, broadening bandwidth is one of the most pressing issues of current technology.

Ponomarenko has joined this quest by developing communication systems that rely on light particles. He studies the ways of using non-spreading optical waves - the so-called optical solution - for the design of ultra fast, broad-band optical systems. He is also looking into the possibility of generating solutions with femtosecond pulses. If generated and used for optical communications, these could significantly increase the available bandwidth.

In addition, Ponomarenko is investigating all-optical networks, where data is transmitted as pulses of light over fibre optic lines. He hopes to find the most particle-like waves that are immune to spreading and that maintain their identity upon collision, thus fulfilling the repertoire of major functions of all-optical networks.

Chair in Photonic Technologies and Applications

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Research involves

Exploring innovative ways to use light properties for faster and more secure communication. The research will dramatically affect the way we live and work by improving the speed and security of communication.

Faster, More Secure Communications Through the Power of Light

Most of us think of light as something that helps us see. But in the Information Age light plays another role: it is used to carry and retrieve information. When we watch a movie on DVD, the information is read by light beams; when we surf the Internet, we send and receive information carried as pulses of light along fibre-optic cables.

Fibre optics is a trillion-dollar global industry that uses light intensity to transmit information. Other properties of light, such as polarization, phase and frequency have not been as widely exploited by the industry. Li Qian, the Canada Research Chair in Photonic Technologies and Applications, is changing that by exploring innovative ways to harness light so that we can communicate faster and more securely.

In her research, Qian works on the development of new devices that are much faster than their electronic counterparts. Her new tools will form the foundation for communication at a speed we can only dream of today. Qian is also coming up with practical solutions for transmitting information securely by light, using its quantum property. When information is sent over the Internet, for example, current encryption methods are vulnerable to new developments in code-breaking algorithms and hardware. Quantum cryptography, based on the laws of quantum mechanics, is unconditionally secure.

The information and communication sector is growing rapidly in Canada and worldwide. Qian's research is driven by both short- and long-term industry needs and is focused on developing practical technologies with commercial applications.

__Canada Research Chair in Nanotechnology__

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Research involves

The development of nanophotonics could lead to ultrafast computer networks and a revolution in how we express and share information

Photonics:

Photonics and nanotechnology take advantage of the fundamental behaviour of light inside novel "designer" materials. These intelligent structures-engineered at nanometer-length scales using the latest breakthroughs in chemistry and physics-are providing the foundation for an entirely new vision of information technology. The resulting devices could be millions of times faster and more powerful than even the most remarkable of today's computing hardware.

Sargent's research has brought this vision of the future into the present. He has created a new type of laser that unites many sophisticated optical devices onto a single, integrated photonic chip. His research links the emerging concept of the photonic circuit with the exploding field of fibre optic networks. Ted Sargent's breakthrough with the lateral current injection laser won him the 1999 NSERC Silver Medal.

Sargent has also shown that a new kind of photonic macrocrystal-one which harnesses nature's underlying drive toward symmetry-will transform how communication networks are built. He works with novel materials that can be induced to organize themselves into specific arrays and patterns, spaced no further apart than the microscopic wavelength of the light which passed through them. He has also developed the photonic heterostructure, which takes advantage of the fact that photons-bundles of light energy-behave both as particles and waves.

As the holder of a Canada Research Chair, Sargent, with his colleagues, will further advance the capacity of innovative nanostructured materials and devices to generate and respond to ultra-high speed streams of digital information. The team will harness the power of laser beams to create low-cost optical components with unprecedented performance.

Sargent's photonics research is not only displacing the electron in computing and communication; it is revealing that these quantum particles-the electron and the photon-may together be exploited through deepened understanding of their fundamental interactions.

Chair in the Theory, Manufacturing and Applications of Photonic Crystals

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Research involves

Speeding up the maturation of photonic crystal technology and its penetration into the industrial sector by perfecting the manufacturing process and development of imperfection tolerant designs.

Research relevance

The research is exploring the possibilities of ultra low loss/nonlinearity fibres and highly integrated planar devices for telecommunications and studying the use of high power delivery fibres at almost any wavelength for medicine and industry.

Photonic crystals, or Photonic Band Gap (PBG) materials, have demonstrated unprecedented potential for manipulating the properties of light. Built as a periodic texture made up of at least two materials with sufficiently different optical properties, photonic crystals become highly reflective in a certain frequency range (also called band gap), enabling one to control light with startling facility and to produce effects that are impossible with conventional optics. These photonic crystals have opened the way to a variety of possible applications including highly compact and reconfigurable telecommunication components, as well as hollow core fibres that exhibit ultra low transmission losses at almost any wavelength leading to unprecedented opportunities for high power laser guidance in medicine and material processing.

The necessity of using a combination materials which are optically and physically quite different from one another, requires complicated fabrication processes that are hard to perfect and model. Moreover, manufacturing tolerances become very stringent when the materials used exhibit a high refractive index contrast, which is typical in PBGs.

Despite the complexity of the problems, he believes that using a systematic ngineering approach that includes the design of imperfection tolerant PBG devices, optimization of the manufacturing process through modelling, and introducing tunability in the post-processing stage, will finally make photonic crystals both technologically and commercially viable

Canada Research Chair in Photonics

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Research involves

Developing ultrafast nano-photonics with ultrafast technology and nanotechnology.

Research relevance

The research is leading to the development of novel applications in information technology and biophotonics.

Enabling Future Photonics

The current opto-electronics industry is challenged by the requirements of miniaturized devices with faster response time for applications in information processing, transmission, and storage. What's needed is the development of an optical nanotechnology that operates at a time scale of femtosecond (one millionth of a billionth of a second) and a length scale of a nanometer (one-billionth of a metre).

Chen is working on just that kind of development. As a Canada Research Chair in Photonics, Dr. Chen investigates new photonic materials and devices that can achieve temporal and spatial resolution in femtosecond and nanometer scales, respectively.

He created new types of optical recording devices and developed ultra-high density optical data storage at the nanometer scale (a huge increase in the storage density over current DVD technology). His breakthrough in ultrafast optical nonlinearity of nano-composite materials shows great promise for all-optical signal processing and switching in future generations of computing and communication networks.

In his present research, Dr. Chen is taking advantage of state-of-the-art ultrafast laser technology and scanning probe microscopes to study the physics and engineering of near-field optics, ultrafast optical spectroscopies, ultrafast photonic materials and light-wave circuits, and biophotonics. He and his team expect their research to reveal new principles, discover enabling technologies, and realize numerous applications for information technology, telecommunication, manufacturing technology, oceanography, and medicine and the life sciences.

__Canada Research Chair in Optical Networks__

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Research involves

Modelling, analyzing and designing efficient methods to carry broadband IP traffic over Wavelength Division Multiplexing-based optical transport networks.

Refining the "Surf" Board

Rapid growth of the Internet is pushing the evolution of information technology and increasingly, telecommunication networks are changing from voice-centric into data-centric networks. As a result, packet switching is emerging as the most efficient and flexible technique for high speed, intermittent data transmissions. But researchers who hope to design the next-generation of high-speed, multi-service Internet networks face significant challenges. Two of the greatest include: developing advanced broadband network control architectures and communications protocols to support the quality of service guarantees over IP networks; and establishing efficient algorithms to manage routing and connections in optical networks.

Housed within the university's School of Information Technology and Engineering, this centre will comprise state-of-the-art laboratories for research in the joint design of the Internet Protocol (IP) and optical layers in broadband information networks. The team will rely heavily on the reconfigurable transmission capacity of the optical layer provided by Wavelength Division Multiplexing (WDM) and on the functionality of the electronic IP layer to develop efficient architectures that reduce the complexity and cost, and improve the reliability of multi-layer networks.

The work includes: developing methods to test, monitor and evaluate the performance of various traffic-, resource- and connection-management techniques for the Next-Generation Internet; designing and implementing more efficient methods to carry broadband IP traffic over WDM optical transport networks; and assessing how advanced network elements might affect the performance and functionality of the optical layer.

Discoveries will be shared with Ottawa's high-tech industry, and with various standards bodies and industrial associations such as the Internet Engineering Task Force. Ultimately, this should lead to the design of highly reliable, cost-effective and flexible broadband information networks that can effectively manage the public's growing demand for electronic services.

Research Chair in Fibre Optics and Photonics

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Xiaoyi Bao
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Research involves

Basic and applied research in Brillouin scattering-based distributed fibre optic sensors, characterization and compensation of the impairment in photonics system.

Development of high speed light sources for applications in communications, fibre sensing and life sciences.
The development of fibre optics and photonics technology has opened enormous possibilities for advanced communications systems, as well as a wide range of emerging applications. One of the major hurdles that must be overcome to allow this new technology to realize its full potential is the existing tolerance levels for polarization and dispersion-related impairments.

Bao's research is aimed at overcoming this challenge by combining the existing methods of single-channel impairment compensation and nonlinear effects control in multi-channel systems. Her proposed approach will permit complete compensation in high speed, multi-channel systems. Her approach will reduce the need for replacement of existing fibres and optical components, a major concern of telecommunications suppliers that have large investments in so-called legacy systems.

Dr. Bao will use her research program to build on existing strengths, such as fibre characterization and compensation for polarization mode dispersion and polarization-dependent loss, the development and application of distributed fibre sensors, and stabilizing laser wavelength and reducing line width. She will also pursue new areas of research, including the study and control of nonlinear optic effects in transmission fibres, novel compensation techniques based on new photonics materials and devices, and the development of new ultra-fast and high power/high repetition rate fibre laser source, soliton lasers and frequency-stabilized lasers.

Among the applications she expects to flow from her work are new sensors for fire detection or leakage from oil and gas pipelines.

Dr. Bao foresees a close collaboration between her lab and the large centre of excellence for photonics that exists at the University of Ottawa.

__Canada Research Chair in Ultra-fast Photonics__

University of Ottawa
Natural Sciences and Engineering

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Research involves

Fundamental and applied research in photonics.

The dynamic field of photonics embraces the use of light beams and optical signals in such far-ranging applications as high capacity Internet transmission, laser-based medical, surgical and therapeutic techniques, and probing and modifying individual atoms and molecules. It is clear that continued cutting edge research in this emerging field promises untold benefits to Canadian society as well as our economy.

Dr. Brabec has spent the last decade building his reputation as one of Europe's leading scientists in photonics. His expertise has advanced work on laser physics, with emphasis on ultra-short pulses, quantum electronics and a new area known as "strong field laser physics

As Chair in Ultra-fast Photonics at the University of Ottawa, Dr. Brabec is now applying his wealth of knowledge to further strengthen Canada's position in this emerging field. A number of researchers from his Vienna team have joined the university's strong team of top researchers already working in photonics-related fields. Under Dr. Brabec's expert guidance, the team is creating a world class research centre for advanced photonics.

Over the next five years, Dr. Brabec's efforts will focus on: developing new concepts for coherent x-ray sources of ultra-short pulses, particularly related to the field of medicine; designing novel tools to advance laser-based eye surgery and optical telecommunications; employing nonlinear optics to design innovative optical telecommunications systems and electro-optic devices, and; advancing fundamental research in strong field physics and its application to materials science. He will also partner with leading researchers around the globe to create an international network of photonics expertise.

Chair in Plasma Applied to Micro- and Nanomanufacturing

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Mohamed Chaker
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Research involves

Studying the role of plasma used in the synthesis and etching of micro- and nano-manufactured materials that can be integrated with photonic and RF components.

Research relevance

Will help advance micro and nano-manufacturing processes to develop photonic and RF components.

Meeting the Challenge of Micro- and Nano-Manufacturing with Plasma

Enormous progress has been made in many high technology fields in recent years, which is partly due to development of new micro- and nano-manufacturing processes used to create advanced materials and structures. Several of these processes use plasma, which provides a medium for carrying out processes that would be difficult, if not impossible, to carry out in conventional physical or chemical mediums.

The research conducted by Dr. Mohamed Chaker at the INRS-Énergie, Matériaux et Télécommunications, will have two main thrusts. He will study plasma used for material synthesis and etching, and integrate these micro- and nano-manufacturing processes to develop radio frequency and photonic components. As an expert on laser-produced plasma, he has an impressive record of accomplishments in the areas of laser-produced plasma for X-ray generation and its applications to X-ray and EUV lithography, laser-produced plasma for new material synthesis and high-density plasma for material etching.

The first component of his research, the synthesis of materials by laser-produced plasma, will focus on the influence of laser pulse duration (subpicosecond to a nanosecond) on the synthesis of metallic silicides, of high dielectric constant materials and of photonic materials. This component will also incorporate a study of high-density plasma etching for producing patterns on the nanoscale. The second focus of the research program is on the production of ferro-electric RF components as well as electro-optical photonic components.

Dr. Chaker's research will contribute to ongoing advanced plasma research, help improve micro- and nano-manufacturing processes, and integrate this micro- and nano-structure technology with the development of innovative RF and photonic components.

Research Chair in Nano- and Micro-Structured Electromagnetic Materials and Applications

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Research involves

Creating new metamaterials with microscale and nanoscale properties.
The research is creating metamaterials that can be applied to telecommunications, defense, and medical imaging.

Innovation on the Nano Scale

Metamaterials are artificially created substances with electromagnetic properties not found in nature. Electronic Engineer Dr. Eleftheriades recently advanced research into metamaterials when he created a planar or "left-handed" lens that bends electromagnetic waves in the opposite direction from what normall happens and offers a very powerful resolution.

Now he is building on his groundbreaking work and taking his research into metamaterials down to the next level.

As the Canada Research Chair in Nano- and Micro-Structured Electromagnetic Materials and Applications, Eleftheriades is creating new metamaterials with microscale and nanoscale dimensions. The technological outcomes of his research program will have wide-reaching applications and set the bar internationally for research into nanostructured metamaterials. Anticipated applications include microwave and optical components and subsystems for wireless telecommunications, near-field sensing and imaging apparatus for defence, and low-cost but accurate equipment for medical imaging and diagnostics.

Chair in Advanced Materials for Microelectronics and Optoelectronics

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Research involves

To develop new high-performance materials to meet the needs of advanced technologies for microelectronics and optoelectronics.

Materials for Microelectronics and Optoelectronics

Researchers working on new semiconductors are approaching the physical limits of miniaturization. And at scales of such minuteness, the very physical properties of a given material may be rather different from those of the same material at larger scales of magnitude. Therefore, to design the next generation of devices and circuits, we need to know more about materials and processes at the atomic level.

Patrick Desjardins, of the École Polytechnique de Montréal, specializes in the science and engineering of advanced materials for microelectronics and optoelectronics, two industries which encompass the fibre-optic telecommunications and data storage and processing industries. The objective of the chair is to develop new materials and new combinations of materials to meet the pressing needs of these industries.

École Polytechnique, the Université de Montréal and the École des Hautes Études Commerciales together founded the Technopole sciences et génie in Montréal. This scientific and technological research initiative will be a national and international powerhouse for converging research in these cutting-edge fields. The chair's work on advanced materials will contribute the development of key aspects of the Technopole's operations in four of its seven priority sectors. The chair will also help attract more world-class professors in this sector which is so essential to the Canadian economy.

As Canada Research Chair, Professor Desjardin's scientific and technological work will have significant impact on such strategically important fields as microelectronics, optoelectronics and nanotechnology. His research will stimulate fundamental work in solid physics while also making available to Canadian researchers new materials and heterostuctures.

__Chair in Ultra Rapid Photonics Applied to Materials and Systems__

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Research involves

The study of ultra rapid technologies that could be used for the analysis and creation of new materials.

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The Infinitely Rapid at the Service of the Infinitely Small

A femtosecond is 1015 times smaller than a second. For example, femtoseconds are used to measure the amount of time it takes the atom to complete its electronic orbit or the time of a molecular vibration. Having observed the infinitely small, we can now also refer to the infinitely rapid. Researchers who focus on the infinitely rapid are engaged in work that is at the frontier that separates the realm of the living and the realm of fundamental physics.

Jean-Claude Kieffer, a researcher at the Institut national de la recherche scientifique, has spent several years studying the sources of ultra short x-rays such as "femtosecond lasers." As a specialist in the interactions between lasers and matter, he has been credited with the invention of the world's fastest camera scanner, a camera that can be used by biologists to, for example, observe and control in real time the changes that occur in the realm of life that they are studying. His research group is considered to be at the forefront when it comes to producing ultra short x-ray impulses, and the tools produced by the group are used by many researchers in North America and Europe.

The overall objective of Dr. Kieffer's Chair will be to develop ultra rapid technologies that can be used for the analysis and creation of new materials. The research work carried out by his team will mostly benefit fields such as microelectronics (screens, memory), photonics, nanotechnologies, telecommunications and biomedical imaging.

Canada Research Chair in Materials Micro/Nanoenrineering Using Lasers

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Research relevance

Development of new surface preparation, processing and cleaning techniques using pulsed lasers (from microsecond to femtosecond), with applications in micro- and opto-electronics, chemical micro-devices, bio-medical devices and micro-electromechanical systems.

Micro-/nanoengineering is used to conceive and produce so-called thin film materials, combinations of materials, micro-structures and nanostructures for applications in fields as diverse as telecommunications, micro-electronics and photonics, aeronautics and aerospace, bio-medical engineering, energy, and advanced materials. Because these types of materials represent enormous potential for highly cost-effective and efficient new technologies, micro-/nanoengineering is a vast and promising field of research that will pave the way to innovation.

Although laser technology has been in wide use since the 1960s, new developments continue to make the laser a highly effective tool for transforming, adding or removing materials such as metals, semiconductors, ceramics and polymers. His work will focus on three complementary areas: understanding the basic phenomena of laser-material surface interactions, through modelling and diagnostic measurements; developing new laser processes using femtosecond (one-quadrillionth of a second) pulses; and applications for the design and processing of new materials, micro- and optoelectronic circuits, micro-electomechanical systems and bio-medical devices.

Specific topics to be addressed by Dr. Meunier and his associates include: the nanoscience of laser-material interactions, which will provide a basis for future applications in laser-material micro-/nanoengineering; femtosecond laser materials processing; the micro-technology of integrated micro-electronic circuits; and the fabrication and application of nanostructured materials by pulsed lasers.

Because of the diversity in current laser-processing and material-characterization equipment, Dr. Meunier's research activities will be very broad, extending from fundamental aspects of laser-materials interactions to the application of laser techniques for industrial purposes

Research Chair in Advanced Polymer Material

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Research involves

Conceptualization and design of novel, nanostructured materials.

Research relevance

Wide-ranging application in areas including telecommunications, security, biomedicine and data storage.

Nano Building Blocks

Dr. Eugenia Kumacheva will pursue four areas of interest in expanding her ongoing research in the field of photonic crystals and initiating novel research in the fields of nanogels, nanoelectrochemistry and self-assembly. The defining feature of all her work is its "bottom-up" approach to the design and creation of nanostructured materials, where individual molecules are first synthesized, maintaining careful control of their size, shape and substituents. These individual molecules and their assemblies serve as building blocks for functional nanostructured materials.

The first component of Dr. Kumacheva's research is the production of polymer-based nanostructured materials with periodic structure, function and composition. The applications for these materials include photonic crystals, which can be employed for optical limiting and switching in optical communications networks, and polymer nanostructured films with periodically modulated fluorescent properties that can be used as encoded security labels.

The second component will be the development of hybrid nanostructured films with unique optical properties.

The third element will be the design of polymer nanogels that have application in biosensing, drug delivery and chemical separation.

Finally, Dr. Kumacheva will develop new strategies for assembling structural blocks of nanostructured materials, including the use of microscopic templates, the effect of surface patterning and a real-time study of the relationship between different factors governing particle assembly under confined conditions.

Canada Research Chair in Quantum Semiconductors

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Research involves

Exploring innovative laser-based methods of quantum semiconductor materials fabrication and bandgap engineering for the purpose of developing a new generation of photonic devices for both information engineering and life sciences.

Research relevance

Manipulating the properties of quantum semiconductor materials will lead to the low-cost development of computer systems for data processing and transmission, and high-performance tools for biomolecular analysis.

Using Quantum Physics to Make Advances in Photonics

Biodiagnostics and telecommunications are two key sectors in society that have taken advantage of the photonics revolution-a revolution in the materials processing as well as is data processing, transmission and storage using photons. It is largely the result of the development of semiconductor quantum materials, which are made up of minute structures (e.g. quantum dots, nanowires, nanotubes, etc.) no bigger than a few nanometres (10-9 m), within which electrons undergo specific quantum effects.

However, the advancements in photonics have not yet been fully exploited: material-manufacturing technologies are far from being fully developed, and we still have insufficient knowledge of the properties of nanostructures. For example, we still cannot produce quantum dots of uniform size that would be adequately distributed on the surface.

Jan Dubowski is an expert in developing innovative methods based on the use of photons for the fabrication of semiconductor nanostructures. As chairholder, he plans to unveil a number of mysteries surrounding quantum dots, wells and wires. He will also endeavour to modify the properties of the above nanostructures at the atomic level with a view to enhancing performance and generating miniaturization of a variety of photonics devices. He will use a number of photon sources (lasers) for the study and high-precision manufacture of quantum semiconductor materials.

One of the most promising potential outcomes of Dubowski's work is the ability to use quantum dots in biodiagnostics and thereby obviate the need to apply today's fluorescent marking methods.

Chair in Ultrafast Photonics and Nano-optics

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Research involves

Development and use of ultrafast lasers and nano-probing optical techniques to explore new phenomena, materials, structures and processes for a wide range of applications for telecommunications and medicine.

Lighting the Way to the Future

The ability to observe and understand structures and materials at the nano (one-billionth of a metre) level holds enormous potential for the development of applications in a number of fields, including telecommunications, semiconductors, material science and life sciences. By using ultrafast lasers and advanced optical sensing methods, scientists can explore the inner structure of matter.

Dr. Abdulhakem Elezzabi's research program seeks to achieve a fundamental understanding of many essential physical processes and phenomena that occur on the femtosecond (a millionth of a billionth of a second) time and nanometer spatial scales. The results of his work have the potential to be used to determine the dynamic structure of proteins in their solid forms with minimal radiation damage, the time-dependent structure of molecules while they undergo chemical reactions, and motion of electrons and atoms in semiconductor quantum devices. The ability to understand processes occurring on femtosecond time scales is pivotal to the development of innovative drug compounds, electronic chips and X-ray imaging microscopes.

Dr. Elezzabi's first project will be to develop a compact table-top laser-based technique to generate and accelerate ultrashort electron pulses using femtosecond lasers. His goal is to develop this femtosecond electron pulse technique as an effective tool for examining many fundamental processes in nature, including atomic and molecular motion, electron transfer dynamics and kinetics, ultrafast phase transitions, and generation of femtosecond X-ray sources.

The second phase of his research will explore the dynamics of charge carriers in high speed optoelectronic, semiconductor, and photonic devices.

His third project will explore the so-called "missing link" in the electromagnetic spectrum (Terahertz radiation), with direct applications to many areas from pollution detection to medical imaging. Dr. Elezzabi will be developing novel techniques for generating efficient sources using high power femtosecond laser pulses.

Research Chair in Computational Nanophotonics

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Research relevance

The research is leading to new applications in such diverse areas as telecommunications, computation, and biotechnology.

Controlling the Nanoworld with Light

Nanomaterials could be the next source of exciting technologies that transform how we work and live. But realizing this potential represents a major challenge: There is a need to find new ways of controlling materials precisely on the nanoscale.

Canada Research Chair Ramunno studies how to control the interactions of light and matter by developing and applying sophisticated computational models. Not only is she investigating how very fast and intense pulses of laser light can be harnessed to shape materials precisely on the nanoscale (at length scales as small as a billionth of a metre), but also how to use such nanostructured materials to control the flow of light in unique and often surprising ways.

Ramunno's work has the potential to revolutionize many areas of technology. It could lead to very small, low-cost integrated optical components that overcome the limitations of existing telecommunications devices and semiconductor electronics, in the latter case dramatically improving the work and accessibility of computer technologies. And in the health sciences, for example, her work could be used to create nanoscale laboratories on a chip and improve laser microsurgery for corneal surgery, as well as manipulate sub-cellular structures to help understand cellular functions, thus opening the door to new, highly-targeted medical therapies. The possibilities for change are almost endless.

Research Chair in Quantum Computation

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Research involves

Reformulating the theory and practice of information processing in a quantum mechanical framework.
Developing the capabilities, and understanding the limitations, of information processing (including computation, communication and information security) in our quantum world.

Security in a Quantum World

One of the most pressing issues in the Information Age is ensuring that the information stored on our computers or transmitted to our colleagues, suppliers, customers, and others, is protected from unauthorized people. Not surprisingly, the sector of the communications industry that develops means of protecting information has grown in parallel with the spread of the Internet and private data networks. The spread of the Internet and the growth of so-called e-commerce have, in fact, been fuelled by the invention of public-key encryption, which relies on the intractability of computational problems like factoring large integers and finding discrete logarithms in specific groups. But, while there are no known efficient algorithms that run on classical computers for solving these computational problems and cracking public-key encryption, it has been shown that quantum computers can be used to defeat these systems.

Building on considerable expertise in the field of quantum computation theory, Dr. Mosca will pursue complementary tasks of finding new quantum algorithms and studying the limitations of various algorithmic approaches. In addition to determining the capabilities of quantum computers, Dr. Mosca believes that it is equally important to understand their limitations. By understanding where quantum computers are not advantageous, it is easier to focus energy in finding tasks for which they are suited. In addition, it is important to discover what types of cryptographic applications will be intractable even for quantum computers.

Collaboration is a key part of this research approach. As well as working in concert with collaborators across Canada and abroad, Dr. Mosca anticipates significant collaboration with Dr. Raymond Laflamme, another leading theorist in quantum computing at the University of Wateterloo and a Canada Research Chair in Quantum Information.

Canada Research Chair in Condensed Matter Physics

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Research involves

Nanoscience and nanotechnology - the study and application of minuscule structures, with linear dimensions of tens of atoms.

Research relevance

Magnetic science; read-write devices for information storage and retrieval; applications for the computer and recording industry.

Manipulating the Atom

In fact, nanoscience - the ability to study and manipulate tiny molecules that measure one-billionth of a metre - is already the topic of cutting edge discoveries and applications in physics. Mark Freeman is at the forefront of that science, where physicists are trying to understand and manipulate complex materials at the atomic level.

Nanotechnology has sweeping applications in the information technology field involving, among other things, the interaction between magnets and superconductors. Already, Freeman has worked with IBM on some of their advanced disk drive products.

Awarding Freeman this chair will enable him to continue to set the agenda in applying nanoscience and nanotechnology to applications that will be fundamental to the computer and communications industries of the future. Nanotechnology will fuel the continuing trend of smaller, faster, more capable devices and products, becoming the engine of the information and computer technology economy at the hardware level.

Canada Research Chair in Materials Science

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Research involves

Study of semiconductor nanostructures using electron microscopy to characterize their properties and relate them to electronic applications.

Working at Nano

The development and evolution of semiconductors has fuelled the growth of the Information Age, in addition to becoming integral parts of everything from wristwatches to household appliances. Within the semiconductor industry, there is a continual drive toward higher performance electronic and opto-electronic components. Key to these gains in performance is the ability to manufacture structures at progressively smaller length scales, which are now approaching nanometers (one-billionth of a metre) in dimension. Properties at the nanoscale are dominated interfacial and material confinement phenomena that are governed by quantum mechanics. The theoretical and experimental techniques for determining fundamental properties at these length scales is still in its infancy and new concepts - possibly distinct from those at the atomic and micro scales - will need to be developed.

That is the basis for the work Dr. Michael Robertson will undertake as Canada Research Chair in Materials Science. His primary objective is to develop the nanoscience framework necessary for the characterization and inter-relation of the physical and electronic properties of semiconductor nanostructures. These nanostructures are critical to the development of the next generation of lasers, to understanding high-speed transistors for the telecommunications industry, and to the eventual creation of a quantum computer.

To investigate structures on the nanoscale, highly focused electron beams are scanned across the surface of a sample. By studying how these electrons interact with the unique arrangements of atoms in each sample, valuable insights are gained into how semiconductor devices emit light and conduct electricity. In addition to the technological applications, methodologies developed for characterizing and understanding these semiconductor systems will find cross applications to other nanosystems in biological, chemical and environmental sciences.

Chair in Nanostructured Organic and Inorganic Materials

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Research involves

Growing and characterizing nanostructures of semi-conductors for nanoelectronics and optoelectronics applications. Depositing and characterizing complex molecules on metallic and semi-conductor substrates

Research and Development on Nanostructured Organic and Inorganic Materials

Federico Rosei developed a nanoscience and nanotechnology research program. He focuses on the following fields: (i) growth of nanostructures of self-assembled semi-conductors and their potential applications in nanoelectronics and optoelectronics"Das semi-conductors have significant properties for apparatus applications, he plans to characterize these properties and correlate them with morphological properties; (ii) interaction of large organic molecules with metal and semi-conductor surfaces, with a view to developing applications for electronics and molecular mechanics.

Rosei has acquired considerable experience in depositing thin layers of semi-conductors and characterizing materials at the level of the nanometre and the atom. Some of his research is devoted to the growth and epitaxis of Ge nanostructures on Si(001) and Si(111) substrates and to the study of their morphological and structural properties.

His recent work also involves depositing large organic molecules on metal substrates and using Scanning Tunneling Microscopy (STM) to characterize them.
Using these new characterization techniques or modifying and refining them, it is possible to study local properties at the level of the nanometre and obtain information that will be invaluable from both a purely scientific and a technological perspective.

Following approval of the Advanced Laser Light Source (ALLS) infrastructure, Professor Rosei wants to work with the laser and wafer teams at the INRS Energy, Materials and Telecommunications Centre on developing the Nano"CFemto Lab by combining the atomic resolution of a microscopy system with the temporal resolution of ALLS.

Nortel Networks -- Canada Research Chair in Emerging Organic Materials

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Research involves

The development of organic opto-electric materials for telecommunications equipment

Fibre-optics Goes Organic

The new Canada Research Chair in Emerging Materials at Carleton University, and world leading polymer chemist, is at the cutting edge of applying organic molecules-from proteins to DNA-to telecommunications equipment.

In his new research position, he will continue his search for innovative organic materials for opto-electric devices. Fibre-optic cables are the best known of these light- and electricity-based communication tools.

As bandwidth demand increases, the fibre-optics industry faces enormous technical challenges to keep up with users' demand for rapid information transfer. Organic opto-electric materials not only can create faster telecommunication systems, but also ones that are less expensive and more easily built.
These carbon-based molecules can be used for a wide variety of opto-electric functions. They could replace existing components that guide the light, detect and receive optical signals, and transduce electrical signals into optical transmissions.

One such high-tech organic candidate is bacteriorhodopsin. This is a photoactive and photochromic (changes colour as a result of light) protein produced by a bacteria. Wang will explore potential applications of the protein for fibre-optic related photodetection and sensing applications. He's currently studying the molecule's potential role in three-dimensional optical data storage and retrieval.

The 20-person student and postdoctoral research team led by Wang will also explore the use of organic polymers as high-speed modulators in fibre-optic systems. These modulators encode electrical information onto optical transmission beams.

As part of his research plan, he will test a prototype polymer-based modulator that would be less expensive and higher-speed than the current modulators.

Research Chair in Communications and Optical Fibre Components

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Research involves

Study of light-grated filters, a basic part of many fibre optic components. Desired objectives could yield important breakthroughs in a crucial area of the new economy.

Fibre Optic Components

The past decade has seen a virtual explosion in the area of fibre optic communications. The increase in demand coupled with new needs have made the emergence of more powerful and efficient high-capacity communications systems critical. Bragg gratings, or spectral filters, are fibre optic components that hold the key to solving several problems encountered by researchers working on improving high-output networks.

The objective as a Canada Research Chair will be to develop new fibre optic components for optical communications systems. Specifically, the team will endeavour to develop new methods for Bragg grating design, writing and characterization.

The Québec area has attracted several photonics research centres. Professor LaRochelle is already part of an extensive collaborative network composed of other universities in Quebec and other provinces. Since Bragg grating-based photonics components are already on the market, opportunities to form partnerships with the private sector are numerous.

__National Research Council-Canada Research Chair in Attosecond Photonics__

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Research involves

Generating extremely short pulses of light, which act like flashbulbs, allowing us to observe molecules and sub-atomic particles during chemical and biological reactions.

Research relevance

In addition to leading to a new light source, this research will allow for better molecular movies, and will offer researchers new ways to observe and control molecules, atoms, and even sub-atomic particles.

Flash Forward: Using Light to Study Electrons, Atoms and Molecules

Probing the secrets of atoms and molecules is one of the most difficult-and important-challenges in all of science. That's because these things, although infinitesimally small, form the very building blocks of the entire world as we know it.

In fact, some things, like sub-atomic particles, are so tiny that we've found them nearly impossible to observe. In the past, the main method used to understand atoms has been to smash them together and see what happens. It's a bit like throwing a baseball at a crowded auditorium, and determining what's inside by the noises you hear.

As Canada Research Chair in Attosecond Photonics, Dr. Paul Corkum is developing new ways to observe atoms, molecules and other tiny particles. To do this, he is building an incredibly fast camera and flash.

The flash operates using electrons which travel at one-tenth the speed of light. If a plane were travelling this fast, it would circle the globe in just one second.

Unlike traditional cameras, which operate in fractions of a second, these speedy electrons allow Corkum to use a far more precise measure of time: the attosecond. One attosecond is one billionth of one billionth of a second. Because it takes just 25 attoseconds for an electron to circle an atom, Corkum's plan is to design the first 25-attosecond flashbulb.

In order to create this flashbulb, he will use a laser pulse to pull an electron away from an atom, and then force it back into a collision, which produces an attosecond burst of light. Using these flashes, he will make "movies" of chemical and biological processes in which the actors are electrons, atoms, molecules, and light.

The movie might observe what happens when a molecule undergoes a simple reaction. The laser pulse could also prod the molecules and use the movie to measure how the molecule responds. Ultimately Corkum aims to observe and control objects in the world of atoms and molecules, just as we observe and control objects in the ordinary world in which we live.

Traditionally, understanding the nature of tiny molecules and atoms has been incredibly expensive and difficult. Corkum's research will provide a new, cost-effective way to learn more about these basic building blocks of matter and life, quite literally shedding light on the fundamental elements of matter.

Research Chair in Digital Communications

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Research involves

Understanding of the fundamental limits of network communications; applying this knowledge to design and test practical, cost effective systems with maximum performance capabilities. Increasing the speed of Internet access in both wireless and wired media.

Practical Solutions for High Speed Internet Access

One of the most pressing issues in establishing the global Internet infrastructure is the development of high-speed local access networks that connect ordinary homes and offices to the Internet backbone. This is because the cost of replacing existing low capacity copper wires and coaxial cables with high speed fibre optics is high. This so-called "broadband access problem" is the most critical challenge facing the next-generation Internet.

Dr. Wei Yu is undertaking research focused specifically on this critical problem. He intends to develop efficient, high capacity communication techniques based on a fundamental understanding of information theory and test them on existing wireless access networks and wired infrastructures. His research will address some of the most fundamental theoretical issues in digital communications and solve practical problems related to widely adopted industry standards, such as the wireless local area network standard, the digital subscriber line standard, and the Gigabit Ethernet standard.

Yu intends to develop a unified theoretical understanding that can be applied to both wireless and wired access media. His two key program objectives include employing theoretical studies to advance knowledge about the fundamental performance limits in multi-user communications, and applying this insight to the design and implementation of cost-effective systems that can operate at maximum performance levels.

Canada Research Chair in High Speed Wireless Communications

Université du Québec, Institut national de recherche scientifique
Natural Sciences and Engineering
514-875-1266, ext. 2011

Sofiène Affes
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Research involves

Validate the STAR-ISR technology by creating a prototype that will be operational in real time and over airwaves. This could help the private sector in Canada develop competitive high-speed fourth generation wireless communication products.

Fourth Generation Wireless Communication Technologies

Cellular telephone communications are advancing with lightning speed, leading to increased demand for high-speed wireless communication services. It is only a matter of a few years before users will have high-speed wireless access to the Internet or be able to run complex multimedia applications over high-speed wireless networks. Dr. Sofiène Affes of the INRS Énergie, Matériaux et Télécommunications, has already devoted much of his research to the development of second generation (2G) and third generation (3G) wireless communications. One of the challenges of moving into the fourth generation (4G) will be the ability to support, at a reasonable cost, multiple and variable transmission rates with different qualities of service (voice, video, data).

Dr. Affes is an expert in telecommunications systems. He used an innovative method of eliminating interference, known as STAR-ISR, for which he currently has a patent application in Canada and abroad. This technique could have enormous potential for future wireless networks, equipment and services, as it could enable a greater number of users to be served, and increase the wireless data transmission rates to which they have access.

The new STAR-ISR technology currently exists as a software program. In the short term, Dr. Affes will seek to validate this technology through the creation of a prototype that will operate in real time and over the airwaves. The long term goal of his research program over the next five years is to improve the STAR-ISR technology so that it can evolve into fourth generation high-speed wireless communications, for which the transmission rates will be about ten to 20 times faster than 3G transmission rates. Dr. Affes' research will focus on the effective use and optimal combination of multiple antennas at transmission and reception sites, using his unique techniques to eliminate interference.

Research Chair in Ultra-wideband Communications

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Xiaodai Dong
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Research involves

The research is leading to the development of new high-speed communication systems and devices for short-range, wireless, personal area networks.

Wireless Freedom

Ultra-wideband (UWB) technology has the potential to be a truly pervasive technology that penetrates everyone's life.

Most computers, computer peripherals, and consumer electronic devices used today require wires for connectivity. For example, data transfer from a digital camcorder or DVD player to a mobile personal computer or an HDTV requires wires. UWB, however, can eliminate these wires, allowing people to "unwire" their lives in new and unprecedented ways.

UWB has versatile applications in home networking, multimedia communications, remote sensing, radar and tracking, public safety and medical use. In addition, as a short-range radio technology, it can complement long-range technologies such as Wireless Local/Metro Area Networks (Wireless LAN/MAN) and cellular communications.

The research focuses on designing, analyzing, and implementing UWB systems for wireless personal area networks. This research includes propagation channel measurements and characterization, low complexity and robust transmitter and receiver designs, as well as network architecture developments.

UWB radio devices, by transmitting at very low power levels, occupy a wide range of frequencies and share the spectrum with existing communication systems that operate in licensed bands, thus allowing more users to co-exist and permitting its use by low-cost commercial devices and systems. The nature of ultra-wideband and the extremely low power transmission of UWB system make its design dramatically different from the conventional narrowband and wideband systems.

__Research Chair in Intelligent RF Radio Technology__

University of Calgary
Natural Sciences and Engineering
403-220-5807

Fadhel M. Ghannouchi
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Research involves

Developing innovative and mixed RF/DSP co-design techniques and approaches for highly spectrum-efficient and power-efficient transmitters. The research is contributing to the development of intelligent RF Radio Technology for broadband wireless communications systems.

Intelligent RF Radio Systems

There is an increasing demand for mobile personal communications and high-speed, broadband multimedia access to the Internet. In order to meet this demand, terrestrial and satellite communications technologies are migrating from the single-carrier narrowband type of application toward the multi-carrier broadband type of applications. New systems are needed to make this shift, systems that are able to provide high-speed data transmission rates, at least on the downlink side. The evolution requires the installation and deployment of specific types of transmitters which are self-adaptive and software-enabled (intelligent), and which can handle the necessary complex modulated signals over a wide range of environmental and traffic conditions, signal formats, and communications standards.

RF energy is a type of electromagnetic energy used to provide telecommunication services such as radio and television broadcasting, cellular telephones, pagers, and satellite communication.) As head of the newly established Intelligent RF Radio Laboratory and in collaboration with the wireless communications industry and government R&D agencies, Dr. Ghannouchi is carrying out leading-edge work into software-enabled RF radio activities. In particular, he is investigating the necessary amplification for modulated signals and developing techniques that will correct for the distortion of the transmitter of the communication terminals. His results are being tested in field conditions with realistic communication signals.

Research Chair in Communication Systems

McMaster University
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Tim Davidson
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Research involves

Recruiting modern optimization theory to develop innovative design techniques for wireless communication systems and bringing high data rate ubiquitous wireless access closer to reality.

Multiplying Wireless Data Rates with Multiple Antennas

One of the greatest attractions of wireless communication systems is their ability to provide access to communication networks from practically anywhere. At the moment, the network we most commonly access is the public switched telephone network (PSTN), which supports standard telephone calls. More and more, however, people want to be able to reach data networks, such as the Internet, through mobile handsets (such as cell phones) and in "quasi-static" scenarios (such as the wireless "Airport" or "WiFi" ethernet systems that are popping up in airports, coffee shops, homes, and offices). Unfortunately, the relatively low data rates of these current systems limit the richness of the (Internet) content that can be provided to, or transmitted from, a mobile wireless device.

Dr. Tim Davidson is looking for ways to design wireless communication systems that overcome these obstacles. He focuses on systems in which the mobile devices and/or the base stations are equipped with more than one antenna. In order for these systems to work well under a broad range of operating conditions, he is drawing on modern optimization theory and state-of-the-art numerical algorithms to develop special design techniques. (Optimization theory relates to the process of improving a system in certain ways, such as execution speed, memory requirements, and bandwidth.)

Dr. Davidson's designs are contributing to the development of future wireless communication systems that will be able to provide higher data rate and "richer content" services in a broad range of untethered communication applications.

Research Chair in Wireless Systems

University of Waterloo
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Amir Keyvan Khandani
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Research involves

Modelling, analyzing, and designing efficient methods to increase the spectral efficiency of wireless networks for fast and efficient implementation of the underlying communication algorithms.

Next Generation Wireless Technology

Future wireless systems are expected to support much higher bit rates at a lower cost. This will impose tremendous pressure on the usage of frequency spectrum, and, at the same time, will require extensive signal processing at the mobile unit. Recent advances in the application of multiple antenna systems predict huge improvements overall, but the execution of the underlying communication algorithms will result in a circuit complexity and power consumption that is well beyond the current capabilities of Integrated Circuit technology.

Therefore, new innovations and breakthroughs are needed to realize these challenging requirements in a cost effective manner. In particular, we need to find solutions for the efficient usage of the frequency spectrum. In addition, we need to find ways to customize the algorithmic design needed to implement efficient circuits.

Dr. Khandani, is working with a solid team of researchers who have the necessary experience to address various aspects of next-generation wireless systems. Aware of the need to have input from many disciplines, Dr. Khandani has put together a collaborative research program that involves experts in developing communication algorithms and designing circuits. His research program links several high impact areas of electrical engineering and has the potential of making important breakthroughs in the design and practical implementation of future wireless networks.

Canada Research Chair in Wireless Communications

The University of British Columbia
Natural Sciences and Engineering
604-822-3515

Robert Schober
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Research involves

Development of new algorithms and designs for wireless communications systems.
Increased reliability and higher rates for wireless communications.

Meeting a Mobile Demand

It is estimated that there are over one billion users of wireless communications devices around the world, including cellular phones, mobile radios, handheld data communication devices, global positioning devices and satellite-based security systems on truck trailers, boxcars and storage containers. New applications for wireless communications are also emerging, such as remote monitoring of hospital patients and medical file sharing that combine with other elements to form what is known as the electronic hospital chart - a cornerstone of the efficiency improvements foreseen by Canada's medical community. For these applications and many others, new high-data-rate services like wireless Internet access and multimedia transmission are expected to be major assets of future communications systems.

To accommodate the increasing demand for wireless data transmission, innovative new transmission systems will be required. As well as making near-optimal use of the available radio spectrum, these systems must be robust enough to ward off interference from other wireless systems, and sophisticated enough to make use of compact power sources.

Dr. Schober has focused the early years of his career on research into diversity schemes and receiver architectures for wireless communications, and as Canada Research Chair in Wireless Communications he will seek to solve some of the key problems in increasing data rates and reliability of wireless networks.

His research will address three specific objectives, the design and analysis of high data rate wireless communications systems; the design and analysis of power-efficient wireless communications systems; and the design and analysis of low-complexity and robust receivers. To accomplish this, he will focus on multiple-antenna communication systems, equalization and interference suppression/cancellation, and non-coherent transmission

Canada Research Chair in Wireless Location

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Natural Sciences and Engineering
403-220-7104

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Research involves

Establishing a new research group to develop super-accurate wireless location systems
Providing new navigation tools and emergency services to cellular telephone users and the transportation industry

Location is Everything

The cellular phone of the future will be expected to go beyond providing communication and Internet service. It will have to serve as a location beacon for the user. Developing super-accurate location technology is the objective of the newly created Wireless Location Research Group (WLRG) at the University of Calgary.

Concerns for public safety have resulted in a U.S. regulation requiring emergency 911 services for mobile telephone customers. The regulation calls for an accuracy of 100 metres, but that will be inadequate for those living in high-rises or working in office towers. These future services will require far more accurate location methods than are currently available.

Other demands for wireless location services include, precision control of agricultural planting equipment, structure monitoring and the need for 3-D marine navigation in constricted waterways. And trucking firms are demanding more accurate ways to keep track of their fleets.

The Global Positioning Satellite (GPS) system cannot adequately meet the needs of these future location-based services. (Signals from the satellite-based system frequently cannot easily penetrate treetops and buildings, and are only accurate to within 20 metres.) New super-accurate systems will soon be under development and testing thanks to funding provided by the Canada Research Chair in Wireless Communication.

The group will be looking at ways to enhance existing systems by augmenting them in a number of ways. GPS systems may one day be augmented by other satellite-based systems and by ground-based transmitters in high-density areas. The signals they transmit often bounce off buildings and other structures causing errors.

Research Chair in Broadband Access Communications

McGill University
Natural Sciences and Engineering
514-398-5252

Tho Le-Ngoc
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Research involves

Developing ways for broadband communications to share resources, such as the telecommunications spectrum, rather than compete for them.
Improving performance and capacity of broadband access communications systems.

Sharing the Broadband Means More for Everybody

As more Canadians use multimedia communications, we are demanding more and better broadband access. However, the spectrum (the range of frequencies available for everything from cell phones to radio stations) is only so broad. And the channels themselves are quite complex. All these devices are sharing the same spectrum and the same resources.

But what if, instead of competing for resources, users of these devices could work together to help each other transmit data, sharing resources to get broader coverage and more open channels? By doing that, you wouldn't need to use large power transmitters, more data could move through the system, and the resources would be used better.

Dr. Tho Le-Ngoc, Canada Research Chair in Broadband Access Communications, is working to develop just such a system. His research program could lead to important breakthroughs in the design and implementation of future broadband access communications systems

__Research Chair in Wireless Communications__

The University of Western Ontario
Natural Sciences and Engineering
613-991-4438

Xianbin Wang
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Research involves

Improving transmission techniques that carry voice and data signals to the millions of Canadians who use wireless devices.

Research relevance

Improving wireless technology will enhance Canada's global competitiveness and ensure that consumers can quickly benefit from the ever-evolving range of services offered by wireless communications.

As Canada Research Chair in Wireless Communications, Dr. Xianbin Wang deals not only with persistent challenges in wireless communications, but also with the problems inherent in a technology that reinvents itself every few years.

At the time of the first cell phone, email was not yet a household word, and text-messaging and hand-held computing capable of downloading spreadsheets or even home videos were still distant ideas. But, these concepts have quickly become the norm, requiring cell phone networks designed originally only to deliver voice-and, even then, not without some difficulty-to transmit all sorts of data, flawlessly and securely. Wang will develop advanced transmission technologies, capable of sending data in even the most hostile environments, using robust channel estimation and tracking techniques.

Wang will work to discover how to make transmission technologies and equipment more adaptable to the ever-changing demands of the end user. Wang will also investigate dynamic allocation algorithms for radio resources, and better designs for overlapping wireless networks.

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Research Chair in Advanced Wireless Communications

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250-721-6028

Aaron Gulliver
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http://www.ece.uvic.ca/~agullive

Research involves

Developing key algorithms and techniques so that people can communicate easily and reliably anywhere, anytime.
Allowing greater capacity and connectivity of wireless devices, as well as a diversity of quality services.

Connecting People Anywhere and Everywhere

There is a tremendous surge in demand for wireless and mobile communications services, such as cellular communications, instant messaging and wireless local area networks (WLANs). In addition, wired technology has advanced to the point where people expect very highspeed real-time services in the home and elsewhere. Therefore, we need new wireless communications systems that use low-cost, intelligent portable devices and that operate in a variety of hostile environments while providing a positive user experience.

The need to interact and participate in a community is very strong, and wireless devices allow a level of connectivity that was unimaginable a generation ago. The impact of new wireless systems and devices on our social and economic future cannot be understated.

Tomorrow's communications systems will deliver high data rate communications; will be efficient in both power and bandwidth; will provide high-quality reliable connections; will allow access anywhere, anytime, over a wide service area; and will provide diversified, easy-to-use services. Gulliver's research is focused on several key enabling technologies that will bring tomorrow here sooner.

But to meet the surging demands for services such as wireless multimedia, we must do more with existing resources. Currently, only about 10 per cent of the available spectrum is in use at any given time. How can users fairly and efficiently use free bandwidth? What happens when ultra-wideband systems allow low-power communications over a wide range of frequencies? Will this mean we can eliminate all wired household communications

__Research Chairs in Future Intelligent RF Metamaterials__

École Polytechnique de Montréal
Natural Sciences and Engineering
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Christophe Caloz
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Research involves

Developing novel electromagnetic metamaterials for the next generation microwave and millimetre-wave devices. The research is providing artificial structures that exhibit exotic properties and represent a new paradigm in microwave engineering for an extended range of new applications.

New Horizons in Electromagnetic Materials and Devices

Metamaterials (MMs) are defined as effective electromagnetic structures that exhibit properties not readily available in nature. Left-handed (LH) MMs, in particular, have spurred great excitement in the scientific world from the first experimental demonstration of an LH structure in the year 2000. LH MMs are characterized by anti-parallel phase/group velocities or negative index of refraction. Science has called them one of the top ten scientific breakthroughs of 2003.

Canada Research Chair Christophe Caloz has pioneered a variety of electromagnetic concepts and subsequent microwave applications that have unique features and performances. An extensive summary of his research and on the field at large can be found in his book Electromagnetic Metamaterials: Transmission Line Theory and Microwave Applications (2005).

Caloz is now working on the development of the second generation of MMs, which is anticipated to be based on miniaturization technologies. He is also working on the integration of additional natural ingredients such as ferroelectric, ferromagnetic, and nano-structured materials. In the process, he is investigating many new types of MM structures (for example, those that are 2D, 3D, terahertz, quasi-optical, nonlinear, active) and MM applications, including advance/delay lines, couplers, phase shifters, mixers, antennas, reflectors, frequency selective surfaces, and ultra-wideband pulse generation and manipulation.

Caloz's research is being carried out at the Polytechnique's Poly-Grames Research Centre, which is a multidisciplinary research group possessing first-rate facilities for analysis, fabrication, characterization, and testing, thus covering all the needs of microwave and milllimetre-wave engineering.

Research Chair in Advanced RF MEMS

University of Alberta
Natural Sciences and Engineering

Mojgan Daneshmand
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Research involves

Examining radio frequency and micro-/nano- electromechanical systems to solve existing problems in mobile communication and wireless biomedical products. Includes development of radio frequency and micro-/nano- electromechanical systems for biomedical applications and mobile and satellite communication.

Microscopic Technology

Micro-electromechanical systems (MEMS are micron-sized enabling technologies make it possible for researchers to develop "smart" products, enhancing what micro-electronics can already do and making it possible to create whole computer systems on a single chip

Daneshmand will devote part of her time as Canada Research Chair in Advanced RF MEMS to applying radio frequency (RF) and MEMS to mobile and satellite communication and biomedical applications, such as "millimetre-wave" MEMS switches and filters, and wireless MEMS biosensors. She will also use the unique characteristics of MEMS devices to solve some of the current problems with RF devices.

For example, Daneshmand will combine the thin and thick film technologies used in creating MEMS to make a low-cost MEMS package (the equally tiny structure around the technology that protects it while letting it do what it's meant to)—one of the major current needs of the RF MEMS market.

They will also look specifically at how RF and MEMS technology can be used to help determine pressure in the brain for patients who suffer from head injuries or brain diseases. Finally, Daneshmand will also see if nano-electromechanical systems (NEMS) technology can be used in biomedical sensing devices, such as pressure sensors and glucose sensors.

As part of her research, Daneshmand will collaborate with the University of Alberta's Biomedical Engineering Department, and, specifically, with its nanotechnology and tissues engineering groups, to get the most out of such potentially barrier-breaking technologies.
The results of Daneshmand's research could not only further expand Canada's burgeoning wireless industry and make it easier to communicate, but could also save lives.

__Research Chair in Wireless Sensor Networks__

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Bozena Kaminska
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Coming to Canada from

USA

Research involves

Developing designs and tools for ultra reliable, very low power miniaturized wireless network components including sensors, relays, and database software for applications in public health and other areas. Applications include monitoring blood pressure, ECG, falls, etc. of people suffering from Alzheimer's and other dementia, and general distributed wireless homecare services.

Miniature Sensors to Aid the Elderly

Dr. Kaminska has already developed a grain of rice sized wireless sensor for use in wildlife management. Now she is turning her attention to health care. Her aim is to provide an unobtrusive miniature device to measure health indicators such as heart rate and blood pressure and send this information by radio to computers and health providers for analysis. The response could be as simple as a recorded verbal reminder to take medication, or something lifesaving like the dispatch of an ambulance.

Networks of miniature wireless sensors have many health-care applications, including diagnosis, monitoring, research, accident prevention, and clinical drug trials. Dr. Kaminska has set up companies in Montréal, Oregon, and California that commercialize wireless sensor systems to monitor everything from wild fish to airline food carts. Now she is building a multidisciplinary team of basic and applied scientists to create applications for wireless sensor networks.

Her miniature wireless sensor solution addresses top priorities of the Canadian government: to prevent unnecessary nursing home additions, improve services, and free hospital beds.

Chair in Radio and Millimetric Wave Engineering

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Ke Wu
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Research involves

Fundamental and applied aspects of radio-frequency, microwave and millimetre-wave (MMW) technologies, with emphasis on innovative development and applications of "substrate integrated circuits" (SICs).
Creating opportunities and multidisciplinary R&D for novel applications such as wireless and optical systems, as well as biomedical and environmental sensors, and intelligent security and control devices.

A New Generation of RF and MMW Technologies

Microwave and millimetre-wave (MMW) technologies have become the focal point in the development of future generations of broadband communication systems and advanced high-speed electronics. Whether the communication systems are in the form of wireless or wireline (optical), mobile or fixed, terrestrial or satellite platforms, MMW technologies are a unique broadband resource and offer unmatched system performance. They represent great potential in such areas as broadband multimedia network for wireless and wireline communications, high-resolution radar for imaging and security, and special electromagnetic devices for biomedical and therapeutic treatment.

Dr. Ke Wu has for many years led Canadian efforts in the development of innovative MMW research programs. In particular, he pioneered a new concept called the hybrid planar/non-planar integration technology, and extended this new concept into a wide range of hybrid and monolithic integration schemes called substrate integrated circuits (SICs).

The Chair in Radio-frequency (RF) and Millimetre-Wave Engineering will establish a unique, high-level RF and MMW engineering research program at Polytechnique, and will encompass both fundamental and applied research of hybrid and monolithic SICs. The program aims to demonstrate the usefulness and importance of this new and possibly revolutionary technological concept as one of the fundamental building blocks for a wide range of RF, microwave, (sub) MMW and quasi-optical circuit and system applications, such as broadband wireless fibre (or radio-over-fibre) systems.

Dr. Wu's program will be greatly enhanced by the Facility for Advanced Millimetre-wave Engineering (FAME), funded by a CFI research infrastructure grant and the Quebec government

Research Chair in Microwaves Antenna

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Natural Sciences and Engineering
613-541-6000

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Research involves

Innovations in microwave and millimeter wave antennas, components and circuits for communication purposes.
Issues to be explored are at the leading edge of technology in the areas of communications, remote sensing, electromagnetic compatibility and interference and other applications of electromagnetics and microwaves.

Electromagnetics:

Wireless, satellite and mobile communications continue to transform our society in many ways, and are becoming increasingly pivotal factors in the growth of information technology. Most of the communication frequency bands allocated to these types of communications fall in the microwave and millimeter-wave frequencies, which are becoming important for applications such as broadband wireless and satellite communication, automotive collision avoidance systems, remote sensing, phased array radars and radar astronomy. All of these applications rely on research in applied electromagnetics.

Dr. Antar will continue his research into innovations in microwave and millimeter wave antennas, components and circuits for communication purposes. He will also investigate some resulting fundamental issues of electromagnetic wave applications and interactions. The main topics of his research include: dielectric resonator antennas; uniplanar and quasi-optical active antennas; phased arrays and smart antennas; electromagnetic modelling and effects; polarimetric techniques in remote sensing; and numerical and analytical modelling.

Dr. Antar's work will bring together research in electromagnetics, and integrated and active circuits through collaborations with researchers at the RMC and several Canadian universities (eg. Queen's University, University of Ottawa, École Polytechnique), government research laboratories (e.g., Communications Research Centre, Canadian Space Agency, Defense Research Establishment) and collaborating industries (eg. Nortel Networks, ComDev, Antenna Industries and ACERAM Technologies).

This research is of vital importance to the training of highly qualified personnel in the area of microwave engineering, where there is a continuous demand for expertise by Canadian industries and government institutions.

Research Chair in High-Frequency Electromagnetics

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Natalia Nikolova
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http://www.ece.mcmaster.ca/faculty/nikolova

Research involves

Applying microwave imaging to biomedical diagnostics and non-destructive testing, via computer algorithms for high-frequency electromagnetic system analysis and simulation, as well as computer-aided design methods for antennas, and microwave devices and systems. Exploring the theory of the interaction of the electromagnetic field with plasma and its application in wireless communications.

Microwave Imaging: a Safe, Simple and Less Expensive Method to Detect Tumours

Imagine a simpler, safer and less expensive diagnostic tool than mammography to detect cancerous breast tumours? Microwave imaging may be just the ticket, but there is work to be done.

An evolving field, and still in its infancy in Canada with no prototype hardware yet developed to test on patients, Dr. Nikolova, would like to make microwave imaging reliable enough to be developed first for clinical tests, then for commercial applications.

In partnership with McMaster's School of Biomedical Engineering, Nikolova is putting together hardware to test " on phantoms"—manufactured objects that mimic parts of the human body, such as the breast—and put objects that simulate tumours in the "phantoms" to perform measurements.

Nikolova is using a vector network analyzer—a microwave measurement tool that measures 16 signals simultaneously—to develop microwave-imaging technology which will allow for regular, frequent, and harmless screening of the female population at risk.

Microwaves are a non-ionizing form of electromagnetic waves that interact with tissues according to water content. Tumours have a higher water content compared to normal tissues. And just as waves scatter when they hit a ship, tumours back-scatter microwaves. Nikolova's research in microwave-imaging will improve the effectiveness and availability of non-invasive methods for detecting tumours.

Research Chair in Applied Electromagnetics

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403-220-6175

Michal Okoniewski
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Research involves

Prototyping, simulation and testing of RF, microwave and millimeter wave circuits, photonics, antennas and micro electromechanical systems.
Development of innovative simulation tools in the areas of wireless, RF/microwave/antennas, photonics and bioelectromagnetics.

Designing with Waves

The area of computational electromagnetics (CEM) - the use of electromagnetic simulations - has emerged from highly specialized academic and military research to become an important tool in the fields of photonics, wireless communications and computer hardware. Many companies in those areas now rely on electromagnetic simulation and design tools to assist them in their R&D projects.

Dr. Michal Okoniewski has gained extensive experience in developing new simulation tools and test devices to analyze problems such as how antennas perform in complex environments and the effect of electromagnetic radiation on humans. A leading researcher in the use of finite difference time domain (FDTD) technology, Dr. Okoniewski has been one of a number of scientists working to develop standards to measure how radiation from cellular phones affects the human brain.

Dr. Okoniewski will work in a multi-disciplinary setting to develop and apply simulation and test tools, as well as design and build devices in a number of areas, including RF/microwave, photonics and biomedicine. His research plan has five areas of concentration: development of a new, non-invasive and painless, diagnostic approach for early detection of breast cancer; evolution of full-wave electromagnetic simulation tools for photonics applications; using existing technology to design new wireless devices (including personal communications services phones and handheld global positioning systems) that minimize the amount of electromagnetic radiation exposure for human operators; development of new computer hardware for faster processing of electromagnetic simulation codes; and designing new photonics devices and RF/microwave components using micro electromechanical systems (MEMS).

Canada Research Chair in Applied Electromagnetics

The University of Manitoba
Natural Sciences and Engineering
204-474-9615

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Research involves

Developing mathematical models for electromagnetic phenomena to design and improve the performance of antennas and the software that controls them.
Improvements in the way antennas operate will increase the quality of wireless communications for a broad range of applications.

Catching the Airwaves

Wireless technology holds an increasingly important role in helping people communicate with one another around the world. Whether that communication involves satellite-based video, global positioning, digital radio, broadband wireless or surveillance of remote assets like shipping containers, the efficiency and performance of antennas is critically important.

One of the research goals is to improve the flexibility of the software that controls antenna and their related sensors and devices, allowing them to be adjusted during operation, ensuring optimum performance.

Dr. Shafai's principal research interest involves two areas of applied electromagnetics and radiating systems. Applied electromagnetics deals with interaction of waves with their environment, and the research involves modelling physical phenomena that influence how antennas operate. To accomplish this, he generates governing mathematical equations and develops suitable numerical techniques to resolve them. The work on radiating systems involves developing antennas and their arrays, sensors or lenses and related microwave components for wireless and satellite communications, remote sensing and radio astronomy applications. The two areas of research are interrelated, with findings in the field of electromagnetics supporting antenna design.

Major developments are expected in the area of radiating systems and antenna arrays, driven by the demand for increased bandwidth and high data rates in telecommunications. While antennas have traditionally been passive devices that operated at low frequencies, new developments have led to antennas being integrated with software that can be programmed to control the devices and improve wireless communications coverage. These developments are particularly important as more data is demanded by users of wireless communications devices, as well as in the area of remote sensing for applications such as flow control in pipelines and security of remote assets.

Research Chair in Advanced Microelectronic Systems Architecture and Development

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Natural Sciences and Engineering
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Yvon Savaria
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Research involves

Basic and applied study of electronic components.
Contributing to the emergence of new micro-electronics technologies

Microtechnologies of the Future

In the last thirty years, the number of transistors, or electronic components, contained in an integrated circuit has doubled about every eighteen months. This is possible because of the significant reduction in the size of transistors, and because of a better understanding of how they work.

Yvon Savaria of the École Polytechnique de Montréal has earned an international reputation for his work on electronic components. He has pushed back the frontiers of science in virtually all areas of micro-electronics (system architectures, algorithmic and heuristic strategies, development of design methods and tools, proposal and analysis of physical structures and circuits). His work has led to the creation of a high-precision circuit manufacturing company. Professor Savaria was a member of the team that launched the micro-electronics activities of the École Polytechnique, and it is largely because of his work that the school is now one of the leading research institutions in this field.

The new chair will be a centre for research on the design of the integrated electronic systems that will take over from existing systems. The chair will also enable Professor Savaria to study potential fields of application such as on-demand video, the design of high-performance switches for telecommunications, and the development of implantable biomedical stimulators.

Research Chair in Microjoining

University of Waterloo
Natural Sciences and Engineering
519-888-4567, etx. 6095

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Research involves

Fundamental and technological aspects of microjoining, including among others, bonding mechanisms, new or improved joining processes, dissimilar material combinations and computer modelling.

Research relevance

Development of advanced microjoining technologies and significant contributions to increased miniaturization of microdevices and microsystems.

Manufacturing complex products depends on the availability of advanced joining technologies. Consequently, microjoining has achieved critical status in terms of demands for scientific and practical advances. Microjoining has its roots in electronic packaging and interconnection, but covers a much broader area, for instance, mechanical support and environmental protection/hermetic sealing. It is essential for manufacturing devices such as medical implants, sensors and transducers, batteries, optoelectronics and micromachines.

His program has several aims, including fostering quality research in microjoining, strengthening the University of Waterloo's position as a global leader in microjoining technologies, training graduate students and providing related technical outreach to industry.

As Chair, he will focus on developing new or improved microjoining processes and on increasing scientific understanding of microjoining. This will include research on topics such as bonding mechanisms and metallurgy, thermal stresses and distortion, and numerical modelling. Several projects will address technology areas of immediate interest to the telecommunications and medical industries, including hermetic sealing and microjoining of advanced materials - particularly dissimilar material combinations.

Dr. Zhou's research results in both the fundamental and technological aspects of microjoining could uncover possibilities for entirely new concepts and configurations of microsystems. Collaborative research will yield immediate benefits for small- and medium-sized companies designing and manufacturing products such as vehicle electronics, telecommunications devices and medical implants. In the longer term, his research is expected to influence advances in nanojoining - the next frontier for materials joining technology.

Research Chair in Microelectronic Materials

The University of Manitoba
Natural Sciences and Engineering
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Douglas Buchanan
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Research involves

Reducing basic transistor size to atomic levels where standard scaling laws fail to apply, so new materials must be introduced in the silicon chip fabrication process to ensure performance targets are met.

Packing Power at the Atomic Level

CMOS (Complementary Metal-Oxide Semiconductor) technology is the dominant semiconductor technology for almost all computers. For the past 30 years, increased chip speed and density has relied upon the reduction in basic transistor size and an increase in transistor density. With continuous decreases in the size of traditional CMOS technology, sizes have now reached atomic proportions, and standard scaling laws fail to be applicable. Since the driving force for the decreasing dimensions is speed to continue increasing performance, an alternative to traditional scaling must be found. We need to develop new high-quality materials to meet industry and consumer expectations.

As the Canada Research Chair in Microelectronic Materials, Dr. Buchanan is examining new high-quality materials that can be introduced during the silicon chip fabrication process, and he is investigating their electronic properties and the effect they have on the operation of fabricated devices. Dr. Buchanan is employing a variety of techniques-including internal photo-emission (optically induced electron injection), capacitance-voltage, current voltage (IV), and photo IV measurements-to study the electronic tapping and de-trapping properties of materials to ascertain their electronic nature. The measurement and analysis of this data will supply feedback to processing engineers to help them make the best products possible.

Dr. Buchanan is also researching the development of new analytical techniques for measuring the physical and electronic properties of these materials. It is this information that will enable the evolution of future CMOS generations.

Research Chair in Electronic Materials and Devices

University of Saskatchewan
Natural Sciences and Engineering
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Safa Kasap
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Research involves

Experimental and theoretical work on photoconductors for medical imaging applications and new photonic materials and devices. This research will create greater efficiencies in the health care system and better care for patients providing efficient, more versatile, photonic devices for optical communications (information highway).

Taking X-rays Digitally

Despite numerous technological advances in the health care industry, x-ray imaging (employing photographic silver halide film) from almost forty years ago still remains in widespread use. At present, x-ray imaging is about 70 percent film based, and extremely inefficient and costly. Digital radiology offers enormous cost savings and other benefits, and with calls for both more efficient health care management and preventive measures such as routine mammographic scanning.

Reduced cost will ensure that radiography is available outside of large, urban hospitals and clinics. Digital radiography will also introduce more flexibility into the system; instead of having to view original films, doctors will be able to process digital images with computers, adding to improved diagnosis.

Dr. Kasap is one of the world's leading researchers on photoconductors. His work on chalcogenide alloy photoconductor materials has contributed to the use of these materials in the new generation of direct conversion flat-panel x-ray image detectors that are poised to revolutionize medical imaging by enabling digital radiology to become affordable and convenient. His research as Canada Research Chair in Electronic Materials and Devices will focus on the properties of various new selenium alloy-based photoconductor films and look toward developing alloys that are even more efficient detectors. Much of the work will be forward looking because commercialization of flat-panel x-ray sensors for applications like mammography.

Canada Research Chair in Electrical Energy Conversion and in Power Electronics

Université du Québec, École de technologie supérieure
Natural Sciences and Engineering
514-396-8874

Kamal Al-Haddad
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Research involves

Theoretical and applied research to design and test new power conversion systems. Development of efficient, non-polluting power converters for a wide range of industrial applications.

Keeping the Power Flowing Efficiently with Less Pollution

One of the most pressing issues facing society is to provide affordable, environmentally safe energy. Energy consumption has been increasing steadily due to industrial requirements and an increase in living standards. Contemporary life depends more and more on the consumption of electrical energy, for both work and leisure. Available energy resources with low-adverse environmental impact are growing scarcer. The addition of new electric plant and transmission lines is becoming more difficult because of economic and environmental considerations. These constraints, together with the increasing demand, mean that new solutions must be found to improve the efficiency of the equipment connected to the power grid, particularly the power electronic converters now widely used as interfaces between the grid and most industrial equipment. Energy pollution and interference created by the extensive use of these power electronic converters could create obstacles to further development in the future.

Dr. Kamal Al-Haddad has gained extensive experience in designing and developing advanced energy conversion systems, including high efficiency, soft switching converters and high frequency power supplies for telecommunications, induction heating for manufacturing facilities, and other various industrial applications. As Canada Research Chair in Electric Energy Conversion - Power Electronics, Dr. Al-Haddad will focus on three key sectors: energy efficiency and electric power quality in electrical distribution networks; power supply sources for telecommunications systems; and electric traction systems for passenger transport.

In addition to conducting fundamental and applied research to develop new technologies, Dr. Al-Haddad will train personnel with the aim of transferring them and the technology to industry. Dr. Al-Haddad and his Group on Power Electronics and Industrial Control have worked closely with industry in the past.

Canada Research Chair in Power Electronics

Queen's University
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Praveen Jain
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Research involves

Telecommunications power electronics and researching efficient and cost-effective power solutions for future processor requirements.

Powering the Next Generation of Information Networks

The computer, broadcast and telecommunication industries are converging to provide a wide range of broadband, multimedia, entertainment, communications and information services.

These emerging information networks require high bandwidth, high-energy efficiency, high availability and reliability at low cost. Power electronics is an integral part of these networks, and the installation of new information systems is expected to double global power supplies sales in the next several years. If the overall efficiency of power generation and transmission can be improved by 20 percent, the reduction in power consumption will result in substantial power generation and transmission cost savings for telecommunication operating companies.

Dr. Jain's earlier work in high frequency resonant converters has changed the design of ultra-reliable and high-density power supplies for telecommunications. The Canada Research Chair will allow him to achieve integrated solutions for powering the next generation processors through the development of new power delivery architectures, and to implement them in industrial telecommunications and computer applications.

This research will help Canadian industries by providing the competitive edge required to penetrate the lucrative global telecommunications and computer market. It will also benefit smaller Canadian companies competing in the power supply market for portable consumer products.

Chair in Powering Information Technologies

McGill University
Natural Sciences and Engineering
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Research involves

Designing novel power electronic converter structures and systems that can be integrated into electric power grids to improve the production and delivery of reliable, high quality electric power for information technologies. These discoveries will vastly improve the quality, reliability and availability of the electric power supplies provided by Canadian utilities and manufacturers.

Enhancing Electric Power for Information Technology

Modern societies rely heavily on information technologies (IT) comprising communication networks, data warehouses, e-commerce, and the control of industrial processes. Such technologies are extremely dependent on reliable, high quality sources of electric power, free from interruption and signal distortion; the slightest power interruption or surge can wreak havoc on an IT infrastructure.

Dr. Géza Joós believes the best way to address the strict reliability needs of IT is to integrate novel power electronic systems with existing and new power grid configurations. In addition to providing a broad range of flexible and cost-effective solutions, power electronic systems allow integration into the power grid of alternate energy sources, such as wind energy and fuel cells, which respond to environmental concerns.
His most significant contributions have focused on enhancing static power converter systems in the medium to high power range and demonstrating the benefits of such systems in terms of improved power delivery, quality and reliability.

Dr. Joós is designing novel power electronic converter systems to enhance the production and delivery of extremely reliable, high quality electric power in order to meet the very strict requirements of IT infrastructures. He is also developing local and centralized control techniques to integrate these power electronic systems into electric power grids that are fed by conventional or alternate energy sources.

The program follows three main research thrusts based on power electronic devices, adding supplemental equipment to enhance power supply quality, adding auxiliary power supplies, and enhancing the reliability and use of the power grid. The specific issues he is addressing are power quality enhancement, integration of distributed generation, and efficient power electronic conversion systems and interfaces.

Chair in Advanced Micro/Nanofabrication/MEMS

The University of British Columbia
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http://www.ece.ubc.ca/~takahata/

Research involves

Developing micro-/nano-scale fabrication methods for functional materials and applying them to MEMS and micro-/nano-machined devices.

Research relevance

Enabling innovative devices for application in a broad range of fields, including miniaturized implantable devices, flexible wireless sensors and micro-/nano-manufacturing machines.
In recent years, we've heard and seen more and more about miniature machines as small as a grain of sand or even a single red blood cell. These machines, known as micro-electro-mechanical systems, or MEMS, integrate mechanical components such as sensors and motors with micro-electronics, making it possible, at least in theory, for them to perform a range of jobs in a microscopic world.
While MEMS could have huge benefits for technology in areas ranging from the health care, telecommunication, and automotive sectors to environmental and safety and security fields, they still have their drawbacks. Some of these have so far kept the technology from doing all it could.

MEMS are made using semiconductor manufacturing technology, and, so far, could only be made from a narrow range of materials, limiting their mechanical abilities. They are very delicate and, in many cases, work only in controlled, clean environments. For these reasons, despite the potential these miniscule technologies have, few MEMS-based products have actually been developed and put to work.

An expert in micro-/nano-fabrication and devices, Takahata has taken a revolutionary approach, diversifying the materials that MEMS can be made with, discovering new things they can potentially do, new strengths that they have, and, as a result, a whole new world of tiny—but enormous—possibilities. For example, his research has already shown that "smart" implants can be made using micro-machined stainless steel, which is both tough and compatible with biological material. These implants can allow doctors to wirelessly diagnose killer conditions such as cardiovascular disease.

Research Chair in MicroElectroMechanical Systems

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Research involves

Designing, fabricating, and testing ultra-small electro-mechanical devices using the most advanced integrated circuit processing techniques.
The project involves the application of fundamental research to commercial products such as sensitive sensors and miniature actuators in the biomedical and telecommunications fields.

Making Small, Thinking Big: Micro-machines for Science and Technology

MicroElectroMechanical Systems (MEMS) devices are miniature mechanical objects that can be fabricated with the well-established tools that are used to manufacture modern integrated circuits. It is now possible to make mechanical objects as small as the component transistors in an integrated circuit, measuring less than 1 ƒYm (1 millionth of a meter). Ideally these mechanical objects can be integrated with electronic circuitry, leading to tremendous cost reductions and increases in yield associated with mass production.

The mechanical objects can serve as sensors or actuators in a number of research and commercial applications, thus replacing conventional technology. As we explore the new applications and new capabilities being facilitated by MEMS, it is becoming increasingly clear that they represent a truly disruptive technology¡Xone that is changing the way we think about and use technology.

Kleiman has designed, fabricated, and used MEMS devices over the last 18 years to study a variety of topics in physics and engineering. For example, he used MEMS devices to study the fundamental properties of single crystal silicon and to measure a novel quantum mechanical effect called the Casimir force. He also helped develop a large-scale optical cross-connect based on MEMS technology, equivalent to an optical switchboard, which is an important component for modern telecommunications systems.

Kleiman continues to use MEMS devices to study fundamental scientific questions and advance the development of MEMS technology for sensor and actuator applications. Furthermore, he is broadening the scope of his research by finding new interdisciplinary applications for MEMS technology including new applications in biochemistry and for biomedical devices.

Chair for Automotive Sensors and Sensing Systems

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Research involves

Developing sensor technology for automotive and intelligent transportation applications. The research is leading to the development of new sensor and actuator technology, components, and systems.

Cars and Computers

Automobile design is undergoing an exciting revolution. As safety and comfort become more and more important to consumers, electronic sensing is penetrating every aspect of automotive design.

Automotive sensing systems interest Wu a great deal. He understands that imaging technologies in the automotive industry are integral to future active safety systems, potentially eliminating collisions and revolutionizing safety standards. That's why this research program focuses on developing automotive-specific imaging sensors and the associated processing algorithms.

The multidisciplinary approach used by Wu involves technologies including wireless sensor networks, intelligent information processing, fusion, and micro fuel cells. The research itself makes the most of key characteristics of Micro-Electro-Mechanical-Systems (MEMS) and Radio Frequency (RF) technologies. By integrating electronics and eliminating cabling, Wu's sensors will be small, inexpensive, and, of course, function better.

The work will undoubtedly lead to the development of sensor systems that are rapidly deployable and likely to have numerous applications in a variety of industrial sectors besides the automotive industry.

Research Chair in Signal Processing Systems

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Research involves

Carrying out algorithm-to-implementation research in the area of microelectronic realization of wireless communication systems. The research will be used to improve the performance and cost-effectiveness of wireless digital communication devices.

Making Wireless Devices More Cost-effective

Our ability to integrate millions of transistors economically in system-on-chip microelectronics is fuelling the convergence of video, audio, voice, and data transport in low-cost, consumer-oriented communication devices. By bringing together several engineering disciplines, developers are coming up with first-rate communication systems that are also cost effective.

One such developer is Professor Gulak, who draws on his background in electrical and computer engineering to carry out his research as the Canada Research Chair in Signal Processing Systems. His current projects rely on a concept known as particle filtering, which is based on Sequential Monte Carlo methods, sophisticated simulation-based methods that provide a convenient and attractive approach to carrying out certain complex computations. Gulak is a believer in the potential of particle filters to improve the performance of different applications in digital communication receivers. At present, he is engaged in exploiting the rich opportunities that exist at the intersection of the mathematics of signal processing and digital communications, digital and analog circuit design, and micro-system design.

Gulak's research builds on the past achievements of his research group, from developing algorithms to implementing the results. His work has applications in channel estimation, detection, and decoding in harsh communication channels. And it is breaking new ground in making silicon implementations available for consumer-level products.

Canada Research Chair in Signal Processing

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Research involves

Detecting, estimating, classifying and designing signals for communication, radar and biomedical systems.
The research is developing new signal processing techniques, and improving wireless communication systems and the diagnostic accuracy of electroencephalogram (EEG) monitoring instruments.

Signaling a New Age of Wireless Communication

There has been an explosive surge in the demands placed on wireless communications systems, requiring more capacity and higher reliability. With so many signals whizzing around us transmitting speech, data and video, we need a system of transmitters and receivers that is up to the challenge.

Improved multi-input multi-output (MIMO) systems may be the answer, according to Wong. He applies specialized signal processing techniques to MIMO systems, with the result that interfering signals are cut down and more of the transmitted signals are detected.

Biomedical signal processing in particular is being affected by Wong's research. By applying advanced methods in signal analysis and multi-channel processing techniques, medical professionals are improving the accuracy of EEG equipment for monitoring patients and carrying out clinical diagnostics of brain function.

Research Chair in Information Systems

Concordia University
Natural Sciences and Engineering
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Research involves

Developing intelligent and secure image processing applications.
This research is enhancing Canada's international position in biometrics-based computer network security and intelligent imaging.

Pushing the Envelope: Intelligent and Secure Image Processing Using Internet

Now that high-speed internet connectivity is so easily available, many people want to be able to operate home appliances remotely and securely by using the internet and mobile communication (such as cell-phones). Dr. Prabir Bhattacharya is helping to develop a biometrics-based system for just such remote appliance control.

Dr. Bhattacharya is also conducting research on the integration of data mining techniques and neural networks to achieve effective and efficient multimedia information retrieval. In today's fast-growing electronic commerce-driven world, there is clearly a need to retrieve and process data from large databases. Content-based image retrieval requires an integration of research in computer vision, artificial intelligence, and databases to address the problem of information retrieval from large collections of image and video frames. And Dr. Bhattacharya and his team of researchers at Concordia are determined to see this happen.

In addition, the team is working on the dynamic scene analysis of objects and developing methods for object recognition from images. This means they are able to analyze scenes that change, such as the weather, in contrast to traditional methods where the idea was to interpret a single image alone. The new methods can accommodate the changes and provide corresponding analysis. As low-cost digital cameras are becoming ever more popular, the potential market for creating computer vision tools for video surveillance and image processing applications using inexpensive digital cameras has become extremely promising.

And finally, in another part of his research, Dr. Bhattacharya is developing an automated system for the interpretation of mammograms. The current costs of mammography screenings are very high due to the significant time involved for medical experts to interpret the mammograms.

Research Chair in Statistical Signal Processing

The University of British Columbia
Natural Sciences and Engineering
604-822-5949

Vikram Krishnamurthy
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Research involves

Fundamental and applied research in statistical signal processing algorithms. This will lead to the development of innovative applications for wireless telecommunication networks, defense networks, bioinformatics and robot navigation.

Innovative Information Technology

Statistical signal processing and network optimization algorithms are critical components in the creation of future applications for many emerging industries, particularly wireless telecommunications, surveillance and target tracking defense networks, bioinformatics and robot navigation systems.

In the world-class laboratory where Dr. Krishnamurthy and his expert team of researchers can conduct their research, quickly test, evaluate and prototype new algorithms, and collaborate with local and national industrial partners and agencies. Their discoveries will foster innovative information technology applications in wireless telecommunications, defense networks, bioinformatics and robot navigation.

Their goals include:
conducting fundamental research to advance state-of-the-art results in mathematical statistics, applied probability theory and stochastic optimization; advancing theory, and developing analysis and design methodologies for future generations of wireless access networks; designing and optimizing integrated target tracking systems in military communications, radar signal processing, and information and electronic warfare; establishing a virtual laboratory to model and simulate wireless telecommunication networks and integrated target tracking systems; and building a critical mass of high quality research personnel for Canada and abroad.

Research Chair in Communication Algorithms

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Research involves

A more comprehensive strategy for developing new information technology algorithms
Better algorithms will be required to keep pace with the growing volume of applications for computer equipment

Improving the Methods Behind the Machines

Information technology has become an obvious fact of everyday life in Canada. Whether we are using a bank machine at the shopping mall, or e-mail at home, we are aware of an unprecedented ability to manipulate text, images, sound, and video.

And we are increasingly aware of the growing potential of this ability. It could ultimately extend to manipulating the information found in the molecules of DNA, affecting the growth and development of living creatures.

In spite of this awareness, the technological underpinnings of this progress are not so obvious. They consist of information-processing algorithms. These are mathematically based sets of commands that make it possible for computer hardware to send, receive, and store data in the form of electronic signals. These algorithms have evolved as the hardware has evolved. But there remains a key distinction between researchers working on algorithms with a theoretical basis, and those who are looking at algorithms in a specific application.

Frank Kschischang has developed a unique research program that brings together these two groups. It's a strategy that is being hailed by software programmers and electrical engineers alike. His work has focussed on the development of algorithms that correct errors that occur in the transmission of information. Kschischang would like to expand this work further, investigating new information-processing algorithms integrated into a continuous spectrum. At one end of that spectrum would be questions of pure theory, while at the other end would be matters of final implementation in products.

Kschischang regards this kind of integration as essential to extending the progress that has already been made in this field. There are numerous directions in which IT is expected to go, all of them with significant economic implications. Improved wireless communications, innovative methods for using the Internet, advanced forms of multimedia, and enhanced security tools.

Research Chair in Autonomic Service Architecture

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416-978-4764

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http://www.comm.utoronto.ca/templatep/alberto.html

Research involves

Developing telecommunication systems that integrate computing and network resources and contain auto-control mechanisms.
The research on self-management mechanisms needed to deliver future applications is leading to new varieties and modes of mobility.

Telecommunications of the Future

In the age of instant messaging and beyond, telecommunications architectures are increasingly defined by multi-tasking and are now unthinkable without the added integration of computing and network resources. Even a standard home computer can simultaneously process e-mail, fax, voice signals, and multimedia conferencing.

Research Chair Alberto Leon-Garcia is developing the architecture for a new service management and control system that largely manages and controls itself, and is able to accommodate a multitude of existing and future applications, thus promising to be highly cost efficient and flexible

He is aiming for the ideal self-regulating management and control system, one that is responsive to ever changing demands and even equipment failure. Such a system will autonomously regulate and optimize configurations of data flow, be able to protect itself from harmful impact - and even have the capabilities to self-heal.

Leon-Garcia's research rests on the cusp of the next technological revolution and his work on the self-management mechanisms required to deliver future applications is opening the door to exciting new technology.

Research Chair in Interactive Network Computing and Teleoperation

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Natural Sciences and Engineering
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http://www.sce.carleton.ca/faculty/liu.html

Research involves

Human-system interfaces, remote control algorithms and data transmission mechanisms for network-based teleoperation systems.
The research will lead to the development of computing technologies that enable people to interact with the environment through networks (such as the Internet) with many applications including remote home health care.

Activity-at-a-distance: Internet-based

Wired and wireless networks are becoming increasingly powerful, accessible and affordable. As a result, network-based applications are rapidly expanding into new areas.

Dr. Liu's research is focusing on Internet-based teleoperation. This revolutionary application allows people to control a tool or a robotic system remotely over the Internet. It has great potential for a wide variety of activities and uses, including telemedicine, distance education, remote environment monitoring, remote crisis management, tele-manufacturing, housework, military, entertainment, etc.

Remote operation over the Internet poses numerous technical problems (such as time-varying delays, limitation and variation of available bandwidth, and reliability), which Dr. Liu is trying to overcome. His research plan consists of four integrated components:

- to investigate the characteristics, effects and compensation of the communication of teleoperation data through the internet under the condition of time-varying delays and not-guaranteed bandwidth;
- to develop data communication mechanisms that are suitable for the characteristics and requirements of teleoperation tasks;
- to develop teleoperation-oriented man-system interfaces; and
- to develop network-based remote compensation control algorithms.

Research Chair in Information Theory and Multimedia Data Compression

University of Waterloo
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Research involves

Extending the application of the universal coding system to include efficient compression of multimedia data files.
The development of superior compression technologies to enhance the storage capacity of computers and make the transmission of data faster and more reliable.

Deflating "Data Balloons"

Imagine a company in the balloon manufacturing business. Once the balloons are made, the flat pieces of plastic are inflated, and then stored in an enormous warehouse. When it comes time to ship the balloons, it takes a fleet of trucks to carry only a few hundred at a time. It sounds ridiculous, but computer users and data transmission servers do this kind of thing every day.

Most data files are stored or transmitted without being compressed. As large hard drives with vast memory capacity have become commonplace, computer users overlook the fact they're wasting valuable space. Data transmission has also sped up dramatically, thanks to the advent of fibre optic networks, but they, too, carry the data equivalent of a shipment of inflated balloons.

Dr. Yang is co-developer of the Yang-Kieffer algorithm, a numerical set of rules employing grammar-based coding to achieve lossless compression of text and image files. Compression programs applying this technique can take the "air" out of "data balloons" and then "re-inflate" them to their exact original size and shape - that's essentially what lossless compression and de-compression is all about.
Dr. Yang's outstanding and novel contribution to the field of data compression and information theory is being recognized by his appointment to a Canada Research Chair. The next phase of Dr.Yang's research is aimed, in part, at developing ways to compress huge multimedia files with as high efficiency as possible. As demand soars for seamless, error-free storage and transmission of sound and video files, new compression technologies are essential.

Canada Research Chair in Internet Video, Audio, and Image Search

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Research involves

Developing and testing speech localization and recognition algorithms.
to advance the field of computer voice recognition, particularly for mobile applications.

Searching for Sound Solutions

All segments of the information technology and communications industries recognize that the next major revolution in their business will be the harnessing of true mobile computing. With the rapid growth of the Internet as the dominant medium for global communications and the massive acceptance of mobile communications devices - ranging from cellular phones to personal digital assistants - comes the realization that the seamless integration of the two will have wide reaching impact. But combining mobility and content-rich communications presents some significant hurdles, not the least of which is consumer acceptance.

One of the key problems in effective mobile computing recognized by Dr. Parham Aarabi is the inability of mobile computing devices to successfully recognize voice commands. While the size of processors has shrunk dramatically and many options exist for replacing traditional monitors, the replacement of the keyboard/mouse with a compact information-entry mechanism remains an elusive problem. Speech-activated control is one option that has exhibited significant promise with desktop computers.

Speech recognition has yet to become the standard for mobile computing because of problems associated with the presence of noise or the change in ambient acoustic conditions. As Canada Research Chair in Internet Video, Audio, and Image Search, Dr. Aarabi will apply findings from his doctoral work on multiple microphone arrays to develop potential solutions to the remote voice-recognition challenge.

The research plan entails four components: devising and exploring new joint speech localization and recognition algorithms that are both robust and practical; adapting these algorithms to the design of microphone arrays that can be deployed rapidly and conveniently; building a test environment to conduct real-time experiments; and developing a sensor network that combines sound localization and speech recognition with other modalities such as infra-red and regular cameras, and floor-based pressure sensors.

Research Chair in Human-Centred Interfaces

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Research involves

Developing new user interfaces to revolutionize the way humans interact with computing technology.

Research relevance

The research is aimed at new technologies, which will greatly enhance the interactive nature of computing and create untold opportunities for sharing information between humans and their technologically enhanced environments.

Creating Revolutionary Designs for Human-Computer Interaction

Imagine being in a board meeting and sharing documents around the room - only the meeting table and walls are "live," akin to huge computer screens, the documents are virtual, and no one has to resort to a keyboard or mouse - or, god forbid, paper!

This is what the future holds according to Canada Research Chair Ravin Balakrishnan. His vision includes three-dimensional displays, which will revolutionize everything from brain scans to online shopping, and audio- and video-based computer systems, which will track and respond to human activity.

His research focuses on enhancing our experience with computing technology and his lab is full of prototypes of technologies that support this kind of activity.

In one room, stands a large projection wall made up of 18 tiled projectors to create one huge image. Above is a series of cameras that track people's movements so that several people can write on the wall at once. It's a crude set-up, admits Balakrishnan, but it's the first step in creating a virtual wall with myriad applications - including a virtual "whiteboard" or a template for ever-changing wallpaper.
In another room of Balakrishnan's laboratory, there's a prototype of a 3-D display that can be seen, simultaneously, from different angles. Using this technology, doctors could have an entirely new way of studying brain scans.

Chair in Distributed and Collaborative Research

Dalhousie University
Natural Sciences and Engineering
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Research involves

Studying and developing resources specific to distributed, often synchronous, research in the sciences.
This research is leading to a better understanding of how people collaborate in advanced research.

Working Together While Being Apart

The ability of groups to collaborate and work effectively at a distance is crucial to modern society. This is true in fields ranging from banking and health care to education and scientific research.

Dr. Borwein is working on ways to help assist this kind of long-distance collaboration, in particular that which occurs between universities and industry, and within and between universities and schools. He is contributing to the development of a laboratory at Dalhousie University, called the Dalhousie Distributed Research Institute and Virtual Environment (D_Drive). The purpose of the lab is to create a supportive environment where display technologies, next generation input technologies, and wireless networking combine to enable highly collaborative and distributed real-time interactions to take place, and as well, to permit the easy meshing of high-performance computing into research interactions.

The lab is devoted primarily to highly mathematical and scientific tasks for which mathematical OCR tools and software are necessary. It is equipped with large, tiled, multi-touch sensitive, high-resolution display panels that allow researchers to interact directly with the panels, rather than through the usual keyboard or mouse. Other lab equipment and technologies include stereo visualization devices for computing and grid collaboration and an Apple G5 computer cluster and file server, as well as wireless for laptops and networking components for other devices, such as cell phones, pagers, and hand-held organizers. In addition, the laboratory contains video equipment to capture and study the facility in action and uses customized software in order to help all the parts work together.

Canada Research Chair in Large-Scale Distributed Interactive Simulation Systems and Mobile Computing and Networking

University of Ottawa
Natural Sciences and Engineering
972-315-1072

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Research involves

Development of algorithms for solving large-scale distributed interactive simulation systems and wireless and mobile computing and networking systems.

Modelling and Designing Large-scale Distributed Wireless and Mobile Networks

The rapid development in portable computing platforms, distributed systems and wireless communication technologies has led to significant interest in large-scale distributed systems and wireless networking to be used for such applications as video entertainment, multimedia Internet access and Internet-based collaborative environments.

These systems are extremely complex and today no one would think of designing such systems without simulating them first. Only through modelling simulation and analysis can system designers obtain the crucial performance characteristics needed to study and evaluate design alternatives.

Dr. Boukerche has already come up with several novel techniques to do just that-to study the performance of complex distributed communication networks. The research team is now developing efficient scalable algorithms for producing high-performance distributed and mobile systems. They are taking an interdisciplinary approach to explore both the theoretical and the practical aspects of large-scale distributed systems and mobile networking.

Dr. Boukerche is focusing on the interoperation and composition of large-scale distributed simulation systems. His studies show how distributed interactive simulation technology can be efficiently applied to real-time applications. His research is leading to the development of methods to evaluate the performance of various data distribution management schemes over wide area networks (including the Internet) for large-scale distributed interactive systems. Data synchronization schemes and routing protocols for wireless and mobile systems are being designed, implemented and tested, and research is being conducted on how advanced wired and wireless network elements affect the performance of these systems.

__Canada Research Chair in Quantum Information Processing__

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Gilles Brassard
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Research involves

The application of quantum mechanics to information processing

Computing Beyond the Speed of Light

In the first quarter of the 20th century, Albert Einstein revolutionized physics with the theory of quantum mechanics. At the beginning of the 21st century, Gilles Brassard is applying quantum mechanics to computers.

Brassard says Quantum information-processing concepts have the potential to create a revolution in computer science. A revolution that could be as spectacular and far-reaching as that created decades ago by the invention of the transistor.

In the late 1970s, he was one of the first researchers to apply the theoretical physics of quantum mechanics to the burgeoning field of computer science-at a time when the notion was thought of more as science fiction than science.

Brassard will continue his groundbreaking work to apply the "spooky action" of quantum mechanics to information processing. Quantum mechanics explains the behaviour of the building blocks of all matter and energy, such as photons, electrons, and atoms. His research will further explore the potential to create quantum computers-capable of performing some calculations faster than a classical computer the size of the universe, at least in theory. This could have profound consequences for the security of transactions on the Internet, as needed for secure Electronic Commerce.

Another area of enormous potential is quantum cryptography, a field in which Brassard has been a pioneer since 1979. Along with his extensive group of international graduate students and postdoctoral fellows, Brassard will seek to determine the conditions under which this quantum-based information privacy system could be practically used, yet unconditionally secure.

In addition to this research, Brassard will continue his research into the fascinating world of quantum teleportation. This makes use of the most fascinating aspects of quantum mechanics to allow for the transmission of quantum information through a classical channel.

Research Chair in Computer Graphics and Animation

The University of British Columbia
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Research involves

Advancing knowledge of movement, computer control systems and robotics to find more effective ways of creating and manipulating animated figures that move and react like humans or animals.
Development of advanced animation systems that can model the natural motions of humans and animals.

Animating Reality

Computer-generated graphics have revolutionized the way motion pictures and video games are produced - increasing the realism for viewers and players in ways that were previously not possible. Yet despite the advancements in technology, modelling realistic motion of articulated figures such as humans remains a significant challenge.

As Chair of Graphics and Multimedia: Motion Synthesis, Dr. Michiel van de Panne will examine ways of developing computational models that mimic realistic and varied human and animal motion.
Dr. van de Panne has established three specific objectives for his research.
The first goal is to develop a computer-driven control strategy that combines the separate areas of data-driven, model-driven and animator-driven control for the first time. Dr. van de Panne will work with existing research on how humans balance themselves and how we react and move as we fall and integrate it into the control algorithms he develops, with the aim of creating a "digital stuntperson" that effectively mimics a variety of human motion skills.

The second goal will go beyond the physics that govern human movement to examine how to program movement that expresses specific behavioural traits and exhibits intelligent planning. The object will be to build predictive models of motion that take into account how specific characters would interact with various environments and situations, such as encountering barriers in one's path.

A third goal is to develop more effective interfaces to allow animators with varying levels of expertise to use a variety of means to achieve the results they desire. The project aims to achieve a better understanding of how interfaces can be designed to work with typical approaches to storytelling.

Canada Research Chair in Information Visualization

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Research involves

Developing effective visualizations in order to create new ways of seeing and manipulating information that will make information more accessible and understandable.
The research will improve our understanding of how to create comprehensible information visualizations that can support our cognitive and communicative activities.

Changing How We See Information

From every direction and every venue we are deluged with information. To make matters more intense, we are generating even more information through the use of various technologies such as space telescopes, satellites, electron microscopes, etc.

The idea of visualizing information to address our comprehension and communication needs arises from an awareness that presenting information visually is so closely linked to our notions of understanding that when speaking casually, the verbs "to see" and "to understand" are often interchanged: the phrase "don't you see?" might be used when what is really meant is "don't you understand?"

Information visualization makes use of computer graphics, human-computer interaction, communication theory, cognitive science, and graphic design in order to develop new types of cognitive aids. Research areas include the creation of visual representations that directly correspond to the information even if that information is abstract or conceptual and has no obvious visual form; the development of interactive techniques that will make it possible to explore and manipulate the representation; and the discovery of how to incorporate viewing cues that will make these visualizations comprehensible.

Information visualization is becoming an indispensable tool that supports many tasks such as communication, retrieval, exploration, manipulation, decision making, and data mining. Information visualization enables people to see their information, to improve their understanding of the information, and thus aid their ability to make decisions based upon the information.

Research Chair in Combinatorial Optimization

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Research involves

Designing algorithms and developing software for combinatorial optimization problems. The research will lead to applications in diverse areas including broadband satellite communications, telecommunication network design, e-commerce, computational finance, and biotechnology, and bioinformatics.

Making the Right Choices

What do a semiconductor manufacturer, a group of genome scientists, and a team of engineers working on a NASA project have in common? All of them rely on computer codes for solving the travelling salesman problem, which is this: given a finite number of cities along with the cost of travel between any two of them, find the least expensive route that takes you through all the cities and brings you back home. The semiconductor manufacturer wants to minimize the length of "scan chains," which are routes included on a chip for testing purposes; the genome scientists want to integrate local radiation hybrid maps into a single consistent map of a genome; the NASA engineers want to save fuel when manoeuvring the pair of satellites used in its StarLight space interferometer mission.

Some of their groundbreaking algorithmic techniques have the potential of being applied to a wide class of combinatorial optimization problems, where one aims to find the most economical option among a finite, but often astronomically large, number of possibilities. At Concordia, Dr. Chvátal and his research team are investigating this potential.

Combinatorial optimization problems have many applications in industry and management. Classical applications include manpower, production, and facility planning; job sequencing and scheduling; manufacturing layout design; retail seasonal planningThe most recent applications are largely dominated by the Internet revolution and advances in genomics. They include broadband satellite communications, telecommunication network design, e-commerce, computational finance, and biotechnology and bioinformatics. These areas will provide testbeds for software developed by Dr. Chvátal and his research team.

Canada Research Chair in Information Technology

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Research involves

New approaches to design, modelling, characterization and applications of advanced semiconductor devices and circuits for information technology applications.

Model and Design to Detect

Microelectronics has largely dominated and defined the information technology revolution in the past three decades. It is expected that nanotechnology - nanoelectronics and nanophotonics - could revolutionize our technological progress in the next several decades. In this revolution, a key component of the new knowledge economy is the ability to store, transmit, receive, manipulate and display information at continually increasing speeds. To do this successfully, we will require the appropriate nanotechnology hardware.

This Canada Research Chair will explore critical nanotechnology components required for long distance communication systems used for data, speech and video in a fiber network; chip-to-chip interconnections in computers; and in areas such as medical imaging and linking of massively parallel processors and mainframe computers.

Dr. Deen is a world-leading expert in modelling, design and applications of modern advanced semiconductor devices and circuits. One of his main areas of research at McMaster University is based on speeding up optical receivers.

The Canada Research Chair in Information Technology will enable Dr. Deen and his team to focus on new physics-based and engineering approaches to modelling, optimization, design, characterization and applications of advanced semiconductor devices and circuits for information technology applications, particularly photodetectors and optical receivers. The calibrated models and designs they will produce are particularly important to industry, allowing those in the industry to manufacture successful new designs that function properly on first fabrication attempt, resulting in significant economic gains.

Research Chair in Electronic Health Information

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Research involves

Understanding the human, organizational, and technological factors that affect the quality and utility of data contained in electronic health records.

Research relevance

The research is using electronic health-care information to improve the quality and delivery of health care. Hospitals in Canada and throughout the world are relying increasingly on electronic health records for the management and delivery of health care.

Electronic health records contain comprehensive data on patients accumulated over time. They offer the promise of reducing health-care costs and improving quality of care and patient safety. Only the quality of the information they contain (e.g., reliability, security, privacy), however, will determine how well this promise is realized. The consequences of poor data can increase costs, the potential for treatment errors, our inability to obtain reliable estimates of disease prevalence, and inaccurate reporting.

El Emam is studying how to improve our understanding of the human, organizational, and technological factors that affect the quality of data contained in electronic health records. His research program asks questions like, how can the quality of the electronic health records be evaluated and how can this evaluation be automated? How good is the data in the electronic health records, especially in the context of mobile communications technologies? What factors, including characteristics of the electronic health record itself, influence the quality of data? And, how can the quality of electronic health record data be improved?

Dr. El Emam wants to understand the economic consequences of poor data so that the benefits of investing in systems and processes leading to improved data quality can be understood and assessed. Although much is known about the quality of paper-based records, much still remains to be done on the electronic side, especially given rapid technological change and increasing use of disconnected mobile systems. Ultimately, Dr. El Emam's research will help to develop and put into practice the tools, guidelines, and standards needed to ensure the quality of health data contained in electronic systems.

Research Chair in Multimedia and Computer Technology

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Research involves

Investigation, modeling and development of solutions for the search, management and transmission of digital media over Internet/wireless networks, and application of the research to various real-world applications such as distance education, telemedicine, e-entertainment, and more.

Making Multimedia Communications Faster, Better, Cheaper

The rapid development of multimedia technologies is profoundly changing the way we access information and how we communicate. It affects how we learn and educate, provide and access services, conduct business and entertain. As digitization and encoding of images and video have become more affordable, computer and Web database systems are beginning to store voluminous multimedia data. However, while data acquisition technology has advanced rapidly, technologies for processing and transmitting multimedia information in large archives have not kept pace.

Dr. Ling Guan has an international reputation in multimedia processing and communications, and some of his most valuable work has been recognized as pioneer work in the field. As Canada Research Chair in Multimedia and Computer Technology, Dr. Guan will continue to make significant contributions to the field with his fundamental and applied research in the coding, indexing and retrieval, analysis and transmission of multimedia data over Internet/wireless networks.

An interdisciplinary research team with diverse expertise - from embedded hardware to high-level application development - will work together within the newly established Laboratory for Multimedia Processing and Communications (LMPC). The integrated and innovative research program will therefore be an investigation of multimedia systems in their entirety from source to destination: data generation (coding), transmission (network management), access (search and retrieval) and delivery to the end-user (human-computer interface) in a most economical way (hardware implementation).

The research team is expected to develop novel multimedia processing and communications techniques that will lead to real-world applications such as tele-medicine, distance education, e-commerce, teleconferencing, security/surveillance, and e-entertainment.

Research Chair in Next Generation Groupware

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Research involves

Examining novel approaches for creating new mass connectivity electronic environments. Research will form the theoretical and practical backbone for the next generation of ubiquitous networks systems.

Enhanced Collaboration

The ultimate goal of these researchers is to create a new virtual electronic environment where a work group spread over several continents, can collaborate as if they were sitting around the same table. Individual privacy is also viewed as an essential design component.

IT has many names for the coming age of connectivity -pervasive computing, ubiquitous collaboration, next-generation groupware. No matter what it is called, the incorporation of communications technology into every aspect of our lives promises to reshape the way we work and live.

The proposed research intends to discover the collaborative devices and structures of the future. It will design new human-computer interfaces, interaction mechanisms, and design the architectures that make them all work together underneath the surface.

Beyond exploring the technical challenges of the coming `age of connectivity', Dr. Gutwin's research will also concern itself with the consequences of connectivity. Methods to protect personal privacy, security, and control of the information environment will also be addressed.

Research Chair in eHealth Innovation

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Research involves

Development of the Program in eHealth Innovation, a joint initiative of the University Health Network (UHN) and the University of Toronto.

Bringing Canada's Health System into the Information Age

Whether publicly or privately funded, health services in most countries are in trouble. Health expenditures are escalating, while the public is increasingly dissatisfied with the care received and worried about the ability of the system to provide high quality, universally accessible care.

Advancement in health information and communication technologies (ICTs) can offer solutions to many of the challenges faced by the health system in Canada. However, there are a number of barriers that block the road to a new health system in the information age. For example, existing health systems were developed in the pre-Internet era, and lack the flexibility to adapt to rapidly changing conditions. Also, health professionals do not have the time or incentives to re-tool themselves or to adapt their practices to the information age.

Jadad aims to overcome these barriers through the development of the Program in eHealth Innovation, a joint initiative of the University Health Network (UHN) and the University of Toronto. eHealth innovation refers to the conceptualization, design, development and evaluation of new ways to use existing and emerging ICT related to health. The Program will support research on how to help people, regardless of who they are or where they live, and use the best available knowledge and eHealth innovations to achieve the highest possible levels of health and to help health systems make the most efficient use of available resources.

Research Chair in Tetherless Computing

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Research involves

Developing and testing new algorithms to solve the theoretical and practical challenges involved in establishing a tetherless computing infrastructure that is secure, seamless, and scaleable. The research contributes to the development of tetherless computing that allows portable smart devices to communicate with powerful computers at high bandwidth, and that may substantially benefit society.

Tetherless Computing

In the emerging paradigm of "tetherless" computing, small, inexpensive, and above all, mobile devices will communicate wirelessly with powerful remote computers at more than 500 times currently available speeds.

Although this is widely agreed upon as the future of computing, there are still a lot of fundamental questions to be answered before it becomes a reality. Dr. Keshav is answering some of those questions. For instance, mobile devices will move in and out of wireless range frequently. How can a mobile device reliably detect the presence of a wireless access point? How can wireless connections be maintained in the face of frequent disconnections? How can a user employ a single identity when establishing connections from different access points?

The solutions to some of these questions require theoretical tools from areas ranging from computational geometry to Markov chain analysis. Dr. Keshav's research benefits from his participation in a wide-ranging, multi-disciplinary research team. In addition, he has built a laboratory test-bed to develop and test exciting new ways to respond to these research questions.

Professor Keshav's previous work has provided some of the underpinning for today's Internet. Routers for example, uses some version of a scheduling discipline he co-invented, called fair queuing.

Research Chair in Information Fusion

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Research involves

Developing advanced multi-source information fusion algorithms for large-scale systems. The research is producing advanced algorithms for multi-sensor fusion for distributed, large-scale systems with both civilian and defence applications.

Fusing Information for a Better Picture

Uncontrolled and unorganized information is no longer a resource in an information society, instead it becomes the enemy." Information fusion represents a response to this awareness that the current deluge of information needs to be controlled and organized so that we can make sense of it. Information fusion is the combining of data from different sources (including sensors, databases, etc.) in a way that provides better information (qualitatively or quantitatively) than any of the single sources involved.

Kirubarajan has been working on information fusion processes for some time. Since it is clear that as sensor accuracy increases, more advanced processing algorithms are needed, he has taken on the challenge. He is developing efficient algorithms that can be used to track the evolving state of a system such as the movement of a plane or an automobile or a tissue cell. His algorithms allow computers to process immense amounts of disparate data, enabling the extraction of all possible information from "noisy" incomplete data derived from many different sources including radar, sonar, imaging sensors, and microphones.

This research is providing innovative approaches to some challenging real-world issues (such as air/ground/maritime surveillance, wireless comunications, and biomedical imaging) in a variety of fields ranging from national defence and communications to biomedical engineering and aerospace.

Chair in Stochastic Simulation and Optimization

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Research involves

Developing and studying effective methods of computer-generated random values and simulating and optimizing systems with random components.
The research will make it possible to produce an accurate computer simulation of the behaviour of complex systems and thus enhance their performance.

Modelling and Simulating Random Phenomena

Computer simulation has become an essential tool in many areas of human endeavour, including science, engineering, management and entertainment. However, specific difficulties arise when the systems to be simulated contain random components. Take the example of a business that does not know ahead of time what the demand for a particular product will be, or that of a communication or transportation network where there is no advance information on traffic volume at each point in the network. In order to use simulations to study and potentially optimize management of systems such as these, the first step required is to build mathematical models that accurately represent the behavioral aspects of interest-for example, quality of service in a network or revenues and expenses of a business. It is then possible to generate a computer simulation of changes in the models and optimize their parameters using specially designed algorithms or heuristics.

Computer generators of random values are a key component of any simulation involving a random variable. They are also an essential feature of computer games, gambling machines (lottery terminals), and communications security systems (cryptology). Quality criteria for generators vary with the application concerned-hence the need to study them from various standpoints and build several types.

Pierre L'Écuyer will devote part of his time as chairholder to developing and studying effective methods of simulating systems with random components and to optimizing systems of this kind by means of simulation-based methods. He will focus on the application of such methods in a variety of fields, including finance, risk management, communications, and management of business operations.

He will also continue his research on the design, mathematical analysis, effective use and statistical testing of generators of random values for a variety of applications. He is recognized as a world authority in this field. At the same time, he wilI study quasi-Monte Carlo methods for large-scale digital integration and the close links between these methods and the construction of high-quality generators of random values.

Dr. L'Écuyer will examine the mathematical and the theoretical aspects of these questions, including algorithm convergence analysis and mathematical analysis of the structure of points produced by generators or by digital integration methods, and the practical aspects, such as software implementation and experimentation.

Research Chair in Privacy and Security

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Research involves

Developing new techniques for analyzing large-scale Internet data.
The research is leading to an increased understanding of Internet behaviour, enabling early detection of malicious outbreaks such as worms, and leading to new protection methods.

Traffic Analysis, the Key to Understanding the Internet

The Internet has grown so rapidly in recent years that it has become increasingly difficult to describe or understand its overall operation..

McHugh's research involves analyzing data that captures a rich set of network behaviours and allows the observer to examine behaviours that range from network wide impacts (for example, the effects of rapidly spreading infectious agents such as the "blaster" and "slammer" worms) and the reactions of a single external host to a powerful distributed denial of service (DDoS) attack. The address space of the monitored network becomes, in effect, a zoom lens but the volume of data collected is such that processing it presents a major challenge.

Part of the challenge is devising abstractions that support reasoning about similar portions of the data. McHugh has come up with a variety of techniques - based on mathematical concepts such as sets and multisets - that allow an analyst to group the data from multiple machines that exhibit similar behaviours. He is also working on techniques that will efficiently represent more complex relationships such as connections and involving pairs of machines on the network.

The data used to pioneer these tools came from a US network, but Dalhousie's participation in national scale networking research and operational networking projects (CANARIE is one example) is making it possible to obtain similar data from Canadian networks.

The tools and techniques developed by McHugh and his team are enabling network managers, researchers, and security personnel to understand the continuing evolution of the Internet and to react appropriately to the challenges it presents.

Canada Research Chair in Algorithm Design

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Research involves

Pure and applied research in algorithm design that
will improve how information is organized on large computer systems to achieve optimum performance within constraints of time and space.

Bringing Order to Chaos

Demands of modern applications are moving from "large" databases comprising a few billion bytes, or gigabytes, of information to specialized systems of several terabytes (one trillion bytes). As demand escalates, the manner in which data is organized and the algorithms (or problem-solving methods) used to manipulate information become increasingly critical. More effective techniques that address time and space constraints must be created to allow large systems to better perform sophisticated searches and updates. In tandem with this application, driven work is the fundamental notion of actually proving that the methods developed are indeed the best possible for the tasks at hand.

Dr. J. Ian Munro is Canada's authority in data structures. His groundbreaking research in the design and analysis of computer algorithms is considered world-renowned. Industry leaders in areas including data warehousing, bioinformatics and embedded computing systems already benefit from innovative techniques Dr. Munro has created to optimize system performance in both time and space.

As Chair in Algorithm Design, Dr. Munro is incorporating both pure and applied research to advance the understanding of the computational complexities of basic data organization and to develop efficient techniques to organize information in large computer systems.

Dr. Munro is using the Canada Research Chair funding to build a world class laboratory for research in data structures and algorithms. The facility will provide his research team with state-of-the-art tools to analyze and develop effective computational methods for application in areas such as data warehousing and bioinformatics. Along with providing an excellent training ground for graduate students, this laboratory will enable the team to test their approaches in "real world" applications, in collaboration with industry partners.

Chair in Information Technology in Health Care

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Research involves

Examining the role of IT in improving and transforming the delivery of healthcare in Canada.

Research relevance

To propose practical approaches to developing the conditions that will enable Canada's healthcare organizations and networks to adopt technological innovations which will have significant impact on the efficiency of the healthcare system and on the quality of care offered to Canadians.

Organizations and the Delivery of Healthcare in the Virtual Age

When one takes into account such contextual factors as the aging population, mass retirements, new, latest-generation medicines and other technological advances, the best bet is that, in the coming years, the healthcare sector in Canada will face greater challenges than ever before. Canadian healthcare organizations are evolving and undertaking major and far-reaching restructuring in order to meet these new demands. Amidst these many changes, they must guarantee quality care for patients while at the same time minimizing costs.

The deployment of information technologies-electronic medical record systems, digital radiology, and telemedicine-plays an important and growing part in the profound transformations that are now a priority in healthcare systems throughout Canada. As Canada Research Chair in Information Technology in Healthcare, Guy Paré will study how healthcare professionals are adopting these technological solutions and integrating them into medical and clinical practice. He will also examine how these technologies are influencing the traditional organizational models characteristic of hospitals and their associated healthcare networks.

Specifically, the research will address three main issues: the relationship between the sophistication of technological innovation and the performance of hospitals; the adoption, diffusion and impact of emerging information technologies in healthcare organizations; and the role of information technologies in establishing and supporting an integrated healthcare network.

Research Chair in Combinatorial Optimization

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Research involves

Combining theoretical and computational approaches to generate algorithms.

Research relevance

Deepening our understanding of combinatory structures with a view to solving large-scale problems, especially those of telecommunications networks.

The Power of Symmetry

What do the following things have in common: the dome of the US pavilion at Expo `67, the SARS virus, and the three-dimensional stable carbon molecule (the discovery of which won the 1996 Nobel Prize for Chemistry)?

They are all "fullerenes," named after architect Richard Buckminster Fuller. In other words, they are all symmetrical geometric structures that resemble the shape of a soccer ball.

The importance of the fullerene lies in nature and humanity's search for stability by achieving maximum effectiveness with minimum effort-a major characteristic of, as the presenter of the Nobel Prize put it, this "unusually beautiful body."

Mathematicians have known about three-dimensional polyhedra since Antiquity, and have studied the more complex ones since the nineteenth century. However, in the late 1940s, the linear programming paradigm gave polyhedra a new importance. This paradigm allows us to explore specific properties of polyhedra to design efficient computational methods. These methods are now applied in a variety of fields including production, transportation, computer science, telecommunications and bio-informatics.

Deza has developed new techniques for using symmetry to solve large-scale problems. As chairholder, he plans to generate efficient algorithms by exploiting the combinatory and geometric characteristics of the problems under study.

Research Chair in Computational Intelligence

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Research involves

Examining the underlying concepts, fundamentals and algorithms (mathematical foundations) of Computational Intelligence (CI); developing new methodologies and techniques of pattern recognition, system modelling and data mining; creating and testing novel applications for industrial use.
Findings will provide a better understanding of the capabilities of Computational Intelligence and lead to improved industrial processes and cutting-edge products that enhance life for Canadians.

Computational Intelligence:

Can you imagine instructing a robot to cook and clean for you? Or telling your vehicle to drive you to work while you finish preparing for that early morning meeting? This might have seemed impossible fifty years ago, but as technology continues to evolve, such concepts now seem quite plausible. In fact, artificially intelligent machines already exist, although their abilities are limited. For example, some computers follow speech or handwritten instructions to perform tasks. Others, called neural networks, learn to solve difficult problems based on previous experiences, just as the human brain does.

CI researchers incorporate science and engineering to design intelligent machines, especially computer programs. The key to CI's success is in determining how to best integrate various problem-solving technologies to create highly effective machines of Computational Intelligence that "think" like people - breaking down problems, dealing with conflicting criteria, and quantifying uncertainty.

Professor of Electrical and Computer Engineering, Dr. Witold Pedrycz, is an international leader in CI development and software engineering. His innovations are highly valued by prestigious scientific organizations in Canada and abroad. In fact, the Institute of Electrical and Electronics Engineers (IEEE) has elected Dr. Pedrycz to IEEE fellow, one of their highest honors. Throughout his career, Dr. Pedrycz has collaborated with top researchers worldwide, and he continues to share his expertise with graduate students to develop highly skilled workers for Canadian industry.

As holder of a Canada Research Chair, Dr. Pedrycz is creating a network of national and international collaborations to build a world-class multidisciplinary centre for CI research at the University of Alberta.

Canada Research Chair in Graph Theory

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Research involves

Development of algorithms to solve complex problems from the theory of graphs and networks.

Research relevance

To understand the structure of large, complex networks and analyze the connections within them.

Network Analysis and Design

Networks are essential to communications, whether the network is the actual structure of a telecommunications system, the World Wide Web or the series of wires on a microchip. Graphs provide an abstract model of network connectivity, and can be used to analyze and predict network performance, as well as to determine the most efficient way of routing traffic along a network. Graphs are used to model the connections in a phone network, the links between Web pages and the wiring diagrams of VLSI chips.

Reed has made significant advances in applying probabilistic analysis to the challenge of determining optimal graph colouring - the assignment of paths followed between vertices, or nodes, on a network. As Canada Research Chair in Graph Theory, he will expand his work on graph colouring, seeking to obtain near-optimal colouring for multigraphs, as well as looking into solving some of the challenges related to frequency assignment for mobile telephone networks.

Another branch of his research will focus on solving practical problems related to VLSI microchip design using tree decompositions and dynamic programming.

A third focus will be on random graphs, with particular emphasis on how they can be applied to the World Wide Web. The differences between the Web graph and other networks ensure that classical random graph models are of no use. Researchers have proposed a variety of random graphs that have some Web-like behaviour but are not sufficiently sophisticated to model it. Dr. Reed intends to develop models that are closer approximations of the Web. This will involve studying current models to understand how they behave and studying the Web to understand its behavior.

__Canada Research Chair in Number Theory__

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Research involves

Use of high performance computers to solve mathematical problems.

Research relevance

Applications for telecommunications and electronic commerce.

New Applications

A key aspect of information technology is the secure and efficient transmission of data. The theory of numbers is of fundamental importance in this connection. Techniques from the geometry of numbers are used in the construction of transmission error-correcting codes - necessary to ensure that data arrives as it was sent - while characters, exponential sums, recurrence sequences and notions of uniform distribution are key components in the design of advanced cryptographic systems that ensure the security of transmitted data. Without number theory, electronic commerce would not be a reality.

Dr. Stewart is one of Canada's leading number theorists. His work in areas such as combinatorial number theory, Diophantine approximation and Diophantine equations - all of which are central topics in number theory - is recognized around the world. He is particularly well-known for his work on the so-called abc conjecture, which is one of the best-known Diophantine equations.

In his program as Canada Research Chair in Number Theory, Dr. Stewart will seek to resolve several open problems in the theory of numbers concerning the distribution of prime numbers, the ranks of elliptic curves, exponential sums and the further study of Diophantine equations.

Given the highly collaborative nature of number theory, Dr. Stewart's work will also be important for the training he provides to the students who will work with him to develop approaches to these outstanding mathematical problems.

Canada Research Chair in Management Informatics

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Research involves

Examining how the design of search interfaces affects human use and how search interfaces should be designed to make them easier and more effective to use.
The research aims to help people find the information they need more efficiently in order to improve the effectiveness of businesses and organizations.

Making Web Research Easier and More Reliable

Despite the phenomenal success of Web search engines and the development of the World Wide Web, people still have trouble finding the information they need and interpreting and trusting what they find. People need information when they're ready to make a decision-and not endless references to documents and pages that are a probable match.

The one-size-fits-all approach, typical of the search box found on Web sites, intranets, and search engines, is not the best way for people to look for information, whether they are trying to locate reliable information about the West Nile virus, about models of digital cameras, or about the government's position on missile defense systems. For this reason, Dr. Elaine Toms is examining ways of enhancing and augmenting the interfaces to content-rich systems, particularly those supporting e-commence and e-government, so that access to the content using search technologies is humanly intuitive and intuitively usable.

Dr. Toms' research on user interfaces melds social science with science. They are working primarily in two areas. In the area of information access, she is investigating how context and task affect how people search. Her research focuses on how interfaces should be tailored to a person's context and to the task the person is attempting to perform.

In the area of information design, Dr. Toms recognises that it is not enough to post/store information; there are many visual and textual factors that affect subsequent use and perception of quality. Her intent is to develop guidelines and templates for information designs that emit trust and credibility.

Overall, Dr. Toms is examining the point of interaction between user and system and the point of interaction between user and content in the context of content-rich systems, especially those used by e-commerce and e-government.

Chair in Adaptive Information Infrastructures for the e-Society

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Research involves

Exploring the latest advances in information technologies that enable human-machine and hardware-software integration.
The research aims to lead to the creation of a systematic framework for the design of Adaptive Information Infrastructures (AIIs), which will advance the field of intelligent, multi-agent systems.

Managing Cyberspace

With more and more Canadians becoming dependent on devices such as mobile phones, personal mobile gateways, and portable players, there is a growing need to manage what goes on behind the scenes in cyberspace.

Dr. Mihaela Ulieru is an expert in intelligent cyber infrastructures, artificial intelligence, privacy and security, e-health, and emergency response management. She believes future information systems will use "surrounding intelligence" to create collaborative ecosystems of stationary and mobile devices. These ecosystems will form an environment that supports complex interactions among living and non-living systems.

In her research, Dr. Ulieru explores the latest advances in the development of information technologies that enable human-machine and hardware-software integration. In particular, she is conducting research on the design and implementation of what are called "adaptive information infrastructures or AIIs."

This new technology is designed to "understand" how to adapt to system and data process changes; it makes the necessary adjustments automatically and is quicker to respond than infrastructures that rely heavily on human intervention.
Dr. Ulieru's work involves the development of computational intelligence techniques that can endow AIIs with learning and discovery capabilities, thus emulating social and biological behaviour. She is looking for solutions to a wide range of logistical problems in areas such as disaster response, national defence and security, and efficient health-care delivery. For example, she is developing a reference model that will enable quick deployment of AIIs for emergency response applications, which will allow dispersed organizations to work together during emergencies by coordinating their activities and helping the best decisions emerge amid the chaos of crisis.

Research Chair in Network and Software Security

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Research involves

Development of new authentication technologies and tools to improve software security. Improved security of communications networks and computer software through better software protection and electronic authentication.

Restoring Digital Trust

As the Internet and wireless communications devices have become the dominant means of voice, data and image transmission, the importance of networked information system security has grown significantly. As the complexity of the global computing and communications infrastructure has grown, its trustworthiness has become uncertain, largely as a result of its dependence on software processes. The vulnerability of critical infrastructures is now recognized, threatening productivity gains. With an increasing amount of financial, medical, industrial and government data moving over networks, the potential losses are enormous, as are the costs associated with computer viruses and worms.

Van Oorschot has garnered a reputation as a leading research scientist and practitioner in the area of advanced computer and network security. As one of the primary developers of Public Key Infrastructure, he played a fundamental role in advancing large-scale deployment of cryptographic security mechanisms including data encryption.

His research program as Canada Research Chair in Network and Software Security will focus on improving the trustworthiness of computer and communications systems. His approach is that by better understanding the vulnerabilities in existing authentication technologies we will be better able to design more secure and easier-to-use techniques. Through a better understanding of software vulnerabilities, especially with respect to malicious software attacks, we can improve the overall quality of computer software systems, and increase the utility and safety of the Internet for conveying and controlling valuable digital content.

One direction of his research will address authentication technologies, seeking to increase knowledge regarding the strength of available authentication technologies in software-based systems, including password-based schemes and recent variations, cryptographic techniques, hardware tokens and biometrics.

A second research direction will address software security. His research will advance automated tools for detecting or defusing exploitable software flaws and develop a better understanding of software properties that contribute to security, with respect to digital content protection and digital rights management.

Research Chair in Mobile Multi-Sensor Geomatics Systems

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Research involves

Investigating the theory and techniques that are critical to the development of cost-effective M2G systems; using the resulting methods and procedures to enhance and develop innovative M2G applications; and advancing real-time M2G geo-computing.

Research relevance

Research will offer field-to-office integrated solutions to support on-line decision making. It will allow real-time mobile information collection, integration and access, leading to significant savings of operational costs and increased safety of field operations.

Innovative Mobile Mapping Systems

The past two decades have witnessed an explosive demand for geomatic data along with an increasing need for data that is more accurate, has higher density, can be produced faster and is cheaper to source. Conventional approaches of acquiring geospatial data are no longer adequate because they are too slow, too labor intensive or do not provide the required information for the application in question.

Geomatics is the science and technology of gathering, analyzing, interpreting, distributing and using geographic information in real-time applications. Emerging as one of Canada's fastest growing technology sectors, geomatics encompasses a broad range of disciplines that results in a variety of practical applications including tracking wildlife, monitoring forest fires, discovering underground oil reservoirs and aiding ships, aircraft and vehicles to navigate safely.

A promising alternative to traditional methods is the use of Mobile Multi-sensor Geomatics (M2G) systems that integrate various positioning, navigation and remote-sensing technologies. What sets M2G technology apart are its independent operation, portability, increased reliability and immediacy. These self-sufficient systems can be easily deployed worldwide by any means of transport, accumulating data from the field in a fraction of the time and cost it used to take. At the same time data can be uploaded remotely and immediately applied as needed.

Dr. Naser El-Sheimy is advancing the theory and applications of M2G systems. His multidisciplinary research program concentrates on the deployment of cost-effective sensing technologies made possible through the development of: Specialized, intelligent processing and sensors integration algorithms; Data management; and Real-time geo-computing

Canada Research Chair in Environmental Sciences

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Research involves

Examining the effects of solar activity on the environment of planet Earth (including geospace), and their linkages with "climate change."
The research will help us predict "space weather" conditions near Earth so as to alleviate detrimental effects on satellites and power grids and assess the impact of space weather on Earth's atmosphere.

Stormy Weather: Storms on the Sun and Their Effects on Planet Earth

The Sun is a dynamic star with frequent storms that send streams of high-energy particles and radiation toward Earth. These storms cause disturbances in the "space weather" of the upper atmosphere, leading to serious side effects on space vehicles, communication satellites, power grids, and Earth's climate.

Dr. St.-Maurice is studying the ionosphere over the Canadian Arctic. For his research, he is using PolarDARN, a new radar developed at the Institute of Space and Atmospheric Studies (ISAS), to measure the winds of the upper atmosphere and relate them to the energetic particles coming directly from the storms of the Sun.

Dr. St.-Maurice is also studying small-scale structures and waves in the ionosphere (1- to 100-metre sizes), using a wide variety of theoretical, modelling, and observational tools such as radars and satellites. He tries to clarify the relationships that exist between metre-size structures and the large-scale (hundreds of kilometres) processes within the northern lights. Like many of us, he has gazed with awe at the brilliant aurora covering the northern winter skies, and appreciated the constantly changing patterns, swirls, and streaks of multi-hues. He hopes his work will illuminate the processes that produce these phenomena.

__Chair in Advanced Geomatics Image Processing__

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Research involves

Developing new technologies for gathering geospatial information from remote sensing imagery. Strengthening Canada's role in the geomatics industry and helping government and academic users improve their geospatial information gathering.

Improving the Information Quality of Far Off Images

Remote sensory imagery and geospatial information does sound like they would be a big part of the average Canadian's life. The fact, though, is that these technologies, and the information that comes from them about our surroundings, are used every day in everything from urban planning and road-access management to disaster monitoring and natural-resource management.

In fact, as much as 80 per cent of the information used to make civilian and military decisions has some sort of geospatial context, meaning it comes from a combination of geographical information and software that looks at space, or distances. But, although billions of dollars have been invested to collect satellite images and provide the latest geospatial information, we still don't have effective technologies to turn these images quickly and inexpensively into the information we need.

As Canada Research Chair in Advanced Geomatics Image Processing, Dr. Yun Zhang is closing the gap between the world's geospatial information needs and what the current technology can offer. The breakthrough technologies he is developing will advance online mapping technologies and increase the capacity of Canada's geomatics industry (the industry that creates tools and techniques for land-surveying, remote sensing, geographic information systems, global positioning systems and earth-mapping) to export remote sensing image-processing software.

Several of the technologies Zhang has already developed have been licensed to world-leading geomatics companies. His automated image-fusion technique, for example, has had a significant impact on the world's remote sensing applications, and is being used across five continents and by leading organizations including NASA, the National Oceanic and Atmospheric Administration, the US Geological Survey, Google Earth, Natural Resources Canada, and the Department of National Defence.

__Canada Research Chair in Cognitive Geomatics__

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Research involves

Understanding the interplay between the ways we think about physical space, and high-tech methods of measuring it.
Create new and improved tools for spatial analysis, and in particular, more user-friendly interfaces.

Good Science Makes Good Neighbours

Geoffrey Edwards' academic training in astronomy and astrophysics is helping people get a better sense of space on Earth. Not outer space, but rather the space around us, including boundaries between neighbours. The result? Spatial tools that are easier to use and understand.

Edwards' expertise spans two diverse realms of terrestrial space: how we measure it, and how we perceive and understand it. Cognitive geomatics is a truly 21st century discipline. It is an amalgam of recent technical and theoretical advances in the sciences of geomatics and spatial cognition.

Geomatics is the science concerned with the acquisition, management, analysis, and distribution of spatially referenced data. Its historical origins lie in surveying, remote sensing, and the data acquisition and "number crunching" capabilities of modern computers.

Most people's first introduction to the discipline is through hand-held Global Positioning Systems (GPS). GPS technology migrated from initial applications in advanced navigation equipment, to low-cost commercial versions used by weekend adventurers.

In 1998, he was instrumental in the creation of the Geomatics for Informed Decisions (GEOIDE) Network, one of Canada's Networks of Centre's of Excellence. This $30 million (1999-2002) R&D investment program involves experts from 24 universities, 27 companies, and 17 government agencies and departments.

One project will develop tools to help judges and legal advisors better visualise land boundaries during litigation trials.

Research Chair in Experimental Cognitive Science

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Research involves

Study of human attention and its relation to perception and thinking.
Provide input to systems designers on how humans react to simultaneous demands for attention.

Technology innovations may make it easier to stay in touch with friends, co-workers and clients, regardless of where you are, or to instantaneously access large amounts of data from around the world.

At one level, psychologists use the term attention to describe the process of selecting one source of stimulation from among many. This type of attention is called "input attention" and can be guided by external signals, such as a sudden onset in the visual periphery, or by internal control. So-called "central attention" involves capacity limitations in post-perceptual categorization, decision making and other operations involving memory, such as encoding, maintenance and retrieval from short-term memory.

Dr. Pierre Jolicoeur's work has involved both types of attention, and his new research will seek to increase our understanding of attention using psychophysical and chronometric methods.

His overall goal is to understand the role of attention in human perception and thinking, as well as failures of attention, which can occur when a person is overloaded with too many inputs or tasks to carry out simultaneously.

Dr. Jolicoeur's program follows three paths, including experimental cognitive psychology, computer simulations and modelling of cognitive processes, and brain imaging to determine how, when and why attention succeeds or fails.

Beyond the direct fundamental science, Dr. Jolicoeur will continue a number of existing collaborations with systems designers in the fields of computing and telecommunications to help develop new generations of devices, such as wireless personal digital assistants, that can deliver information in an effective and safe way. One aspect that is of particular interest is the determination of the limitations on human consciousness to undertake multiple attention-demanding tasks such as driving a car while talking on a cellular telephone.

Research Chair in Communication and Society

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Research involves

Improved understanding of the social, political, economic and cultural implications of decisions regarding information and communication infrastructure.

Re-thinking the Information Society

As much as any political upheaval or international conflict, the last two decades have been dominated by the emergence of digital technology and the spread of wireless communications. Information has become a valuable commodity, and the development of the Internet holds the promise of creating new economic opportunities around the world. Understanding this potential, and the relationship between new technologies and cultural change is essential because the decisions that have been made and those to be made in the future will have a profound impact on society.

In his research program, Dr. Mosco will look at the social, political, economic and cultural dimensions of mass media, telecommunications and information technology. His program is unique in the breadth of its coverage, as it will focus on four interrelated areas of study.

In the second stream of his research he will focus on secular trends that are shaping the telecommunications industry in an attempt to form a broadly based view that goes beyond short-term business cycles of boom or bust.

Third, Dr. Mosco will assess the consequences of "technopoles" - concentration regional centres of technology based industries. Examples include California's Silicon Valley, Ottawa's so-called Silicon Valley North, Kuala Lumpur, Malaysia and the emerging Emilia Romagna region of Italy.

Finally, they will develop a best practices analysis of the use of communication and information technology in learning.

Research Chair in Vision and Behavioural Science

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Research relevance

Methods for analysis and synthesis of animate motion will prove useful to motion modeling in computer animation and telecommunications and to clinical movement analysis.

How Our Brains Perceive Animate Motion

When you notice someone in a crowd, your brain performs a range of complex computations, integrating information from a variety of different sources such as the person's facial features, posture, voice, scent-and the way that person moves. The way a person moves reveals a multitude of psychologically and socially relevant attributes. We can recognize friends by the way they walk and we can attribute gender, age, emotional expression, and personality traits to perfect strangers based entirely on their actions, gestures, and facial movements (that is, their animate motion). This ability to recognize different patterns of motion is often overlooked in the study of human perception and the way our visual systems achieve this so effortlessly is still a riddle for vision scientists.

Dr.Nikolaus Troje studies how information is encoded in biological motion patterns and how it can be retrieved from them. His aim is to understand the mechanisms used by the human brain to recognize visual motion. As Canada Research Chair in Vision and Behavioural Science, Dr. Troje combines computational modelling with visual psychophysics and physiological testing techniques. In his experiments, human observers are presented with real, modified or artificially generated displays of human motion patterns and they have to solve tasks such as sex classification, person identification and recognition of emotion. Comparing the performance of human observers with computational models can reveal principles how the brain processes information. Visualizing brain activity with modern imaging techniques offers insight into the involvement of different areas and circuits in the brain.

In-depth knowledge about the way in which humans perceive motion, combined with techniques for generating artificial motion patterns and modifying relevant features of the motion patterns, is the basis for applications in telecommunication and computer animation. To this end, Dr. Troje hopes to develop products that help computer animators generate realistic, psychologically convincing biological motion for computer-generated characters.

APPENDIX A

Government of Canada strengthens research excellence by investing $113 million to fund 127 Canada Research Chairs

OTTAWA, Tuesday, June 10, 2008 — The Honourable John Baird, Minister of the Environment, on behalf of the Honourable Jim Prentice, Minister of Industry and Minister responsible for the Canada Research Chairs Program announced an investment of $113 million to fund 127 Canada Research Chairs (CRC) from 35 universities across the country. The Canada Foundation for Innovation (CFI) is also contributing $4.8 million to fund research infrastructure essential to the work being performed by 33 of the chairholders.

"Our government recognizes the key role that the Canada Research Chairs Program plays in building on Canada's growing reputation as a global leader in research and innovation," said Minister Baird. "Guided by the S&T Strategy, and reinforced in Budget 2008, our government is working to mobilize science and technology to our country's long-term economic and social advantage."

The Canada Research Chairs Program is designed to attract the best talent from Canada and around the world, helping universities achieve research excellence in natural sciences and engineering, health sciences, and social sciences and humanities.

"The Canada Research Chairs Program helps to position Canadian universities as world-class research centres," said Chad Gaffield, President of the Social Sciences and Humanities Research Council and head of the CRC Program's steering committee. "With the help of funds from the CRC Program, researchers are finding solutions to today's social, health and economic issues and are training the next generation of innovative scientists and scholars."

- "The investments being announced will further enhance our country's reputation as a destination of choice for the world's top minds," said Dr. Eliot Phillipson, President and CEO of CFI. The partnership between the CRC Program and CFI has been instrumental in achieving this, and today's announcement ensures that this trend continues.

Canadian universities both nominate Canada Research Chairs and administer their funds.

Each eligible degree-granting institution receives an allocation of Chairs. For each Chair, a university nominates a researcher whose work complements its strategic research plan and who meets the program's high standards.

Three members of a college of reviewers, composed of experts from around the world, assess each nomination and recommend whether to support it.

Types of Chair

There are two types of Canada Research Chair:

Tier 1 Chairs, tenable for seven years and renewable, are for outstanding researchers acknowledged by their peers as world leaders in their fields. For each Tier 1 Chair, the university receives $200,000 annually for seven years.

Tier 2 Chairs, tenable for five years and renewable once, are for exceptional emerging researchers, acknowledged by their peers as having the potential to lead in their field. For each Tier 2 Chair, the university receives $100,000 annually for five years.

Appendix B

The Government of Canada has taken unprecedented steps to compete in the global research market, retain the best minds in Canada, and attract the brightest new talent from around the world. In May 2007, the government introduced the **Science & Technology (S&T) strategy** designed to turn ideas into innovations that provide solutions to environmental, health, and other social challenges while also improving economic competitiveness.

"The two programs are important extensions of the S&T strategy," continued Minister Prentice. "They will empower people, strengthen knowledge, and encourage entrepreneurial advantages to build a strong Canada for the future."

The **CERC** program will award 20 Chair holders and their research teams with up to $10M over seven years to establish ambitious research programs at Canadian universities. When fully operational, the Vanier CGS Program will support 500 Canadian and international doctoral students each year with three year scholarships valued at up to $50,000 per annum. Both programs are a tri-agency initiative of the Social Sciences and Humanities Research Council (SSHRC), **Natural Sciences and Engineering Research Council** (NSERC) and Canadian Institutes for Health Research (CIHR). The CERC program is administered by the Canada Research Chairs Secretariat, which is housed within SSHRC. The Vanier CGS program is administered by each granting agency and coordinated by the Canada Research Chairs Secretariat.

"The Canada Excellence Research Chairs Program and the Vanier Canada Graduate Scholarship Program will promote the development and application of leading-edge knowledge and position Canada as a magnet for the world's top research leaders and doctoral students," said Dr. Chad Gaffield, President of SSHRC. "They will attract candidates of the highest calibre including leading academics in every field."

Appendix C

Selected Topics of Interest in Current Wireless R&D

- Context-aware computing
- Cross-layer design
- Green Pervasive computing
- Security in Wireless and Pervasive systems
- Wearable Devices
- Sensors and RFID in Pervasive systems
- Sensors in Environment monitoring
- UWB
- Sensors and RFID in Health Care
- Multimedia in Wireless networks
- Wireless Network and architecture designs
- Wireless smart vehicle systems and networking à WiMAX
- Cognitive Radio systems
- MIMO systems
- Cooperative communications systems
- PCS, GPRS, EDGE, 3GPP, UMTS, GSM and B3G systems
- Localization and tracking techniques
- Pervasive computing applications
- Pervasive communication architecture
- QoS Support in wireless systems
- Air interfaces (e.g. CDMA, OFDM, TDMA)
- Fault-tolerant and resilient sensor networks
- Pervasive e-services
- Wireless smart artifacts