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The ECE Department at the University of Toronto ranks first in Canada according to 2013 QS World University Ranking.

The past year has been one of growth, change and discovery in the ECE Department. With 78 research faculty, more than 1,200 undergraduate and 500 graduate students, ECE hums with energy. We have made progress over the past 12 months we have undergone one external review, scaled up our offerings, and enrolment in the Masters of Engineering (MEng) program, have undergone two external reviews, scaled up our offerings, and enrolment in the Masters of Engineering (MEng) program, and have enrolled into an Alumni Board of Advisors, and invested in our students and infrastructure.

In May 2013, we presented the results of an exhaustive self-study to an external review committee composed of faculty members from leading Canadian and American universities. The group evaluated our department on its academic programs, research, organizational and financial structure, long-range planning and internal and external relationships. The results were released in September 2013, and the review committee praised the outstanding quality of our faculty, research, students and programs. Also this past academic year, our undergraduate program underwent a thorough review by the Canadian Engineering Accreditation Board to ensure its compliance with professional engineering standards. The Board renewed our accreditation and gave ECE a glowing review.

As part of our ongoing focus on strengthening ties with industry and practicing engineers, we continue to expand our MEng curriculum and admissions. We have now rolled out five courses designed specifically and exclusively for MEng students, in electronics, computers, power systems, and two in communications. We also saw MEng enrollment reach the 150 mark including both full- and part-time students.

As chair, I am delighted to announce the formation of ECE’s Alumni Board of Advisors. This diverse group of graduates and industry leaders met throughout the year to consult on and assist with the department’s alumni and advancement activities and strategic direction. You can find profiles of our board members in this issue’s Community section (page 26).

Finally, the University of Toronto’s Boundless Campaign is fully underway and ECE is dedicated to raising support for more graduate student scholarships, ambitious renovation of our Energy Systems Lab, and the new Centre for Engineering Innovation & Entrepreneurship, which is slated to break ground in 2014. The stories in this magazine highlight the successes of our world-class students, faculty, partners and alumni. I hope you find the issues both informative and enjoyable, and I hope it makes you proud of this department, as I am. I welcome your comments and feedback on this publication and our direction—you may reach me at chair@ece.utoronto.ca.

Iron Ring

Many Canadian-trained engineers wear an iron ring on the pinky finger of their working hand. This tradition originated with University of Toronto mining engineering professor Herbert Haultain after the collapse of the Quebec Bridge in 1907, a construction disaster that killed 75 construction workers and was caused by poor planning and design, and inadequate diligence by the project’s engineers. Professor Haultain wished to create stronger bonds between engineers and remind them of the obligations and ethics inherent to their profession. He enlisted the help of English writer Rudyard Kipling (author of The Jungle Book) to create a dignified obligation and ceremony known as The Ritual of the Calling of an Engineer, where new engineers undertake the obligation and receive their rings. The iron ring is worn as a symbol of the engineer’s responsibility to society.
The Undergraduate Experience

Seated at the heart of most technical advances made today, electrical and computer engineering is the engine that powers 21st century technology. An undergraduate degree in electrical and computer engineering offers the widest range of career opportunities.

The Edward S. Rogers Sr. Department of Electrical & Computer Engineering at the University of Toronto offers the broadest curriculum in Canada, making it the school of choice for both third and fourth year, students choose an area of specialization. In both third and fourth year, students may choose from six areas of study, depending on their individual strengths and interests. The options include: Photonics and Semiconductor Physics; Electromagnetics; Analog and Digital Electronics; Communications, Systems Control and Biomedical Engineering; Computer Hardware; and Computer Software.

In third year, students choose an area of specialization. In both third and fourth year, students may choose from six areas of study, depending on their individual strengths and interests. The options include: Photonics and Semiconductor Physics; Electromagnetics; Analog and Digital Electronics; Communications, Systems Control and Biomedical Engineering; Computer Hardware; and Computer Software.

Curriculum streams have been designed to help guide students; however, students are free to create their own unique path of study. Learn more about the eight curriculum streams at uott.me/ececurriculum.

Undergraduate Awards

Academic Awards
Each year ECE recognizes the top three students in both Electrical and Computer Engineering with ECE Outstanding Student Awards.

The Sachtman Medal is awarded annually to two students in the graduating class who have earned the highest cumulative grade point average in Electrical and Computer Engineering. For 2012–2013 the recipients were Zhi Li (CompE) and Weijian Zhou (BScE).

The CNB Hochhausen Prize for Excellence in Accessible Design in Engineering for People who are Blind or Partially Sighted was awarded to Vastaf Iqbal, Ahmad Dab Marzouk and W. A. Kavindu Gayanath Amarasingha for their design project titled “Navigation System for the Visually Impaired.”

The Gordon R. Slater Design Award was awarded to Miad Fard, Richard Medal and Mehrad Mashayekhi for their project titled “Digitally Configurable Lab Platform for Design-Oriented Teaching of Analog Electronics.”

The Alpka Design Award was awarded to Leon Chan, Guo Qin Low and Chia Chen Tan for their project titled "FPGA Video Processing – Cartoonizer.”

Design Awards
Engineering is about more than marks—teamwork, creativity and execution are essential to success. Each year ECE awards three prizes for teams who have demonstrated excellence in their final year design projects. For 2012–2013:

The Professional Experience Year (PEY) internship program has been running for more than 20 years and has earned a terrific reputation in both academic and industry circles. PEY offers students an outstanding education, a range of eligible engineering career paths to choose from and strong established industry partnerships. This year, PEY placed students in more than 150 companies located around the world: Canada, the United States, Belgium, Germany, Finland, China and South Korea.
Since 1996, when a small group of Mechanical and Electrical Engineering students formed the Advanced Solar Electrical Vehicle Program. The 21-member team unites students from across Engineering departments, and is supervised by ECE Professor Olivier Trescases and Mechanical & Industrial Engineering Professor Kamran Behdinan.

The Blue Sky team achieved its goal of finishing in the top 10 among 23 teams from around the world. Blue Sky's car, B-7, completed the race in 45 hours and 38 minutes, achieving an average speed of 65.71 km/hour. The team recorded its journey online and in video, and live-tracked the vehicle throughout the race.

Built and driven entirely by students, B-7 features the latest advancements in photovoltaic technologies, a brand new aerodynamic design and improved vehicle dynamics systems. It weighs about 20 per cent less than its predecessor, Azure, which placed 24th out of 37 teams in the 2011 World Solar Challenge.

Blue Sky Solar Racing has been building and racing solar cars since 1996, when a small group of Mechanical and Electrical Engineering students formed the Advanced Solar Electrical Vehicle Program. The 21-member team unites students from across Engineering departments, and is supervised by ECE Professor Olivier Trescases and Mechanical & Industrial Engineering Professor Kamran Behdinan.

The Next 36 is a prestigious entrepreneurship leadership initiative helping to launch business careers for promising Canadian undergraduates.

It aims to transform participants into Canada's top entrepreneurs through a rich offering of in-kind resources and instruction from some of the world's top faculty.

ECE student Nikita Tarakanov was selected among the 2013 Cohort. His venture, Sesame IO, is a cloud-based work environment geared towards saving teachers’ time.

IEEE

The Institute of Electrical and Electronics Engineers (IEEE, pronounced eye-triple-e) is the world’s largest professional association, dedicated to advancing technological innovation and excellence for the benefit of humanity. With more than 425,000 members in more than 160 countries, IEEE’s objective is to build a network of professionals and students in the electronics field and to promote the latest technological developments through conferences and published literature.

University of Toronto’s IEEE Student Branch is the largest such branch in Canada and hosts numerous conferences, tours, dinners and networking opportunities throughout the year, as well as technical seminars and academic sessions aimed at preparing students for the professional and academic world.

This year two ECE students were honoured with IEEE scholarships worth $2,000 each:

- Yue Lu received the IEEE Canada Toronto Section, Bruno N. Di Stefano scholarship
- Chuanwei Li received the IEEE Canada Toronto Section scholarship.

WISE

Women in Science and Engineering, or WISE, is a co-ed student organization open to all University of Toronto students, staff and alumni.

WISE offers activities and outreach programs designed to facilitate networking opportunities between students and professionals from a variety of industries. The group provides a welcoming, supportive environment through social events and a mentorship program that aims to foster positive relationships during university and after graduation. Established in 1999, WISE arose as a forum for peers to share their experiences. With support from the University and student body, this chapter of a national association has developed into a recognized campus organization.

GLEE

This spring, U of T’s Faculty of Applied Science & Engineering welcomed more than 90 newly admitted female students with the Girls' Leadership in Engineering Experience weekend—also known as GLEE. Attendees got the chance to learn more about student life and seek guidance from current engineering students, faculty and alumni.

Now in its second year, GLEE is an initiative that aims to inspire graduating female high-school students to join the U of T Engineering community. The young women are joining a community where women are leaders in their fields, making a positive impact as educators, researchers and entrepreneurs.

Purple Power Lighting Event

Undergrads lit the CN Tower in purple to celebrate National Engineering Month in March.
The Edward S. Rogers Sr. Department of Electrical & Computer Engineering consistently ranks among the top ECE departments in the world. Throughout its history, ECE has been witness to groundbreaking discoveries and developments in almost every area of electrical and computer engineering, at the core of which is the outstanding research conducted by graduate students and faculty members.

Supervised by our faculty of 78 professors, many of whom are leading experts in their fields, graduate students may choose from a wide range of research areas including biomedical engineering, communications, computer engineering, electromagnetics, electronics, energy systems, photonics, and systems control.

ECE offers three degrees: Master of Applied Science (MASc), Master of Engineering (MEng), and Doctor of Philosophy (PhD).

The Master of Applied Science degree provides advanced study and research in a major field. This is a full-time program and requires the completion of courses, a thesis proposal, and a research thesis. The MASc is the recommended prerequisite for admission to a PhD program.

The Master of Engineering degree provides advanced training to individuals who wish to work or practice in the field of engineering. This course-based degree may be completed on a full- or part-time basis. It is not a research degree and is not a recommended prerequisite for admission to the PhD program.

The Doctor of Philosophy degree is intended for those who wish to pursue a career in fundamental or applied research. The PhD requires the completion of courses, a field-comprehensive examination, a thesis proposal, and a research thesis. Applicants to the PhD must hold the equivalent of an MASc degree with thesis. For admissions information visit uoft.me/gradadmission.

Graduate Research 2013–2014

Enrolment in ECE Research Stream Programs

Graduate Enrolment, 2003–2004 to 2012–2013


ECE at the University of Toronto ranks 19th internationally according to QS World University Rankings 2013.
From 2009 to 2013, ECE inventors disclosed 163 inventions. In the same period, we filed 19 patent applications, signed 24 licenses and formed 16 start-ups.

Vanier Scholars
Two ECE PhD candidates were selected as NSERC Vanier Canada Graduate Scholarship (Vanier CGS) recipients for 2013:

Mohamed Abdelfattah
Supervisor: Professor Vaughn Betz
Project title: “Communication-Centric Architectures and Design Styles for Next-Generation Programmable Systems-on-Chip”

Amit Deshwar
Co-supervisors: Professors Brendan Frey and Quaid Morris
Project title: “Computational Methods For Gene Expression Analysis of Heterogeneous Samples”

Worth $50,000 per year for three years, the Vanier CGS program is designed to attract and retain world-class doctoral students and help establish Canada as a global centre of excellence in research and higher learning.

Interdisciplinary Problem-Solving: ECE 1778
You use your smartphone for calls, texts and email—but do you use it for treating addiction, diagnosing disease or teaching children? Smartphones are tiny computers with built-in microphones, cameras, accelerometers, magnetometers and GPS—when approached imaginatively, their capabilities are virtually limitless. Professor Jonathan Rose encourages imagination in ECE 1778: Creative Applications for Mobile Devices, the interdisciplinary graduate course he launched. The course is open to graduate students from all fields across the University of Toronto. Students with non-programming backgrounds are grouped with programmers, typically from Computer Science or Electrical & Computer Engineering, and teams work together to realize the design and functionality goals of the non-programmer, or ‘apper’. The course ran for the third time in Winter 2013, and resulting applications have helped new Canadians acclimatize to a different culture, varsity athletes rehab from ankle injuries, and parents decide how much fever medicine is safe for their child. “We have a diverse set of apps, and that’s because of people who aren’t in the field jumping in,” says Professor Rose. “That’s what we can do uniquely here at U of T, being so interdisciplinary—once you work with these ideas, lots of exciting things happen.” Professor Rose is launching a new research centre with a related focus: The Centre for Inter-disciplinary Mobile Software and Hardware, which seeks to put extensive effort into developing high-impact mobile applications in a variety of areas.

“Thad’s what we can do uniquely here at U of T, being so interdisciplinary—once you work with these ideas, lots of exciting things happen.”
--Professor Jonathan Rose

Spin-off companies sparked by ECE in the last 15 years

From 2009 to 2013, ECE inventors disclosed 163 inventions. In the same period, we filed 19 patent applications, signed 24 licenses and formed 16 start-ups.
The Research Perspective

Researchers at the University of Toronto strive to make discoveries that will influence industry and benefit society. We do so by tackling challenging fundamental and applied problems; working across and beyond disciplinary boundaries; partnering with industry, government, and other academic institutions globally; and training the research leaders of tomorrow.

In The Edward S. Rogers Sr. Department of Electrical & Computer Engineering, we are particularly proud of our ability to identify areas of strategic importance to global industry and society and to address these important problems. Initiatives include:

First, our focus on the Smart Grid, the electrical grid that seamlessly incorporates renewables such as wind and solar, and uses the latest technology to improve the efficiency, importance, reliability, economics, and sustainability of electricity services. This initiative leverages our strengths in energy systems, systems control, algorithms, optimization, security, communications, networking, electronics, and photonics;

Second, our emphasis on the technological, economic, and social dimensions of security and privacy in the mobile ecosystem and the emerging cloud;

Finally, our strategy to bring electrical and computer engineering expertise to important problems in biomedical engineering and medical devices, uniting expertise in sensors and stimuli, low-noise and low-power electronics, systems-on-chip, signal processing, systems control, optoelectronics and computing.

Our researchers partner with countless industry leaders worldwide to stimulate, enable, and translate our research into application. ECE continues to seek unique ways to make a global impact, benefiting Canada and the world through advances that improve quality of life.

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The Research Perspective

ECE Invention Disclosures, 2009 to 2013

ECE is top five at U of T in new priority patent applications filed and new patents issued.

Canadian Peer Universities vs. University of Toronto Share of NSERC Funding for Electrical and Electronic Engineering 2012 (Grant Year = April to March)

Professor Aleksandar Prodić
Professor Peter Lehn
Both named U of T Inventors of the Year

University of Toronto
University of Waterloo
McMaster University
University of British Columbia
University of Alberta
McGill University
École Polytechnique de Montréal
Queen’s University
University of Ottawa
Concordia University
University of Calgary
Simon Fraser University
École de technologie supérieure
Institut national de la recherche scientifique
University of Manitoba
Carleton University
University of Victoria

University of Toronto ranks 22nd in the world for Engineering and Technology according to the Times Higher Education World University Rankings 2013.
ECE faculty held 23 research chair titles in 2012–2013, including Canada Research Chairs, Endowed Research Chairs, Industrial Research Chairs and U of T Distinguished Professor Chairs.

Early Career Teaching Award
Professor Jason Anderson received the Faculty of Applied Science & Engineering’s 2013 Early Career Teaching Award, which recognizes an instructor in the early stages of his career who has demonstrated exceptional classroom instruction and teaching methods.

Sustained Excellence in Teaching Award
Presented to a faculty member who exhibits teaching excellence over a sustained period of time. This award is new this The first recipient is Professor Tarek Abdelrahman for 2012–2013.

Distinguished Professor in Application Platforms and Smart Infrastructure
Presented to Professor Alberto Leon-Garcia. He was also named a Fellow of the American Association for the Advancement of Science.

Fellows of the Royal Society of Canada
Professors Frank Kschischang and Jonathan Rose

Fellow of the Engineering Institute of Canada
Professor Paul Chow

$261K
Average research operating funding per ECE faculty member

ECE Research Funding from 2005–2006 to 2011–2012

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<td><strong>$16,946,833</strong></td>
<td><strong>$17,925,106</strong></td>
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A Year to Remember
Professor Joyce Poon was announced as the 2013 recipient of the University of Toronto’s McCharles Prize for Early Career Research Distinction.

She is the third recipient of the McCharles Prize, which was established in 1907 by Aeneas McCharles and re-established in 2007 as an award for exceptional performance and distinction in early career research on the part of a pre-tenure member of the Faculty. Professor Poon is a Tier 2 Canada Research Chair in Integrated Photonic Devices.

Already considered a thought-leader in her field, her research focuses on the creation and exploration of novel photonic devices. Professor Poon received an Early Researcher Award in 2009. She garnered IBM Faculty Awards in 2010 and 2011 — the only Canadian to receive this prestigious award in either year. In 2012 Professor Poon was named one of the world’s Top 35 Innovators Under 35 by MIT Technology Review.

ECE professors Brendan Frey and Steve Mann were among 12 expert speakers selected to present at TEDxToronto 2013. Canada’s largest TED event, TEDxToronto is an independently organized program that builds on the central TED concept of sharing ‘ideas worth spreading’.

TEDxToronto

Publications by ECE Faculty, 2003 to 2012

ECE is the top department in the Faculty of Applied Science & Engineering for all commercialization indicators in the past five years. ECE typically accounts for about 50 per cent of Faculty start-up companies and invention disclosures.
Discoveries are Made with Teamwork
From Software to Circuits with LegUp

This summer, while their peers were travelling, relaxing and working, four of ECE’s top undergraduate students put their education into action.

William Cai, Emily Miao, Yolanda Wang and Yvonne Zhang got a real taste of research working on LegUp, a project jointly supervised by Professors Jason Anderson and Stephen Brown. LegUp is a high-level synthesis tool that lets software programmers benefit from the advantages of hardware — primarily speed and power efficiency — without struggling to learn complex hardware design languages. It’s the first high-level synthesis tool that’s completely free and open-source, and that is robust enough to handle realistic programs.

The end result is a reconﬁgurable ﬁeld-programmable gate array, or FPGA, tailored to perform certain compute-heavy chunks of the program much more efﬁciently than software alone. Think of a program as an assembly line: in order to get the ﬁnished product, thousands of simple tasks must be performed in sequence. Software can be like running an assembly line with only one person on it — that worker can only complete one task at a time until the job is done. Incorporating parallelism, through FPGAs, is like adding many more people to the line. The additional workers can do many tasks simultaneously, and the ﬁnished product is produced more quickly.

LegUp is much more than just a great idea — it really works, right now. Launched in March 2011, the source code has been downloaded externally more than 600 times since its ﬁrst release, and the ﬁrst LegUp paper has already been cited more than 70 times. The group has presented for companies such as Intel, Samsung, Xilinx, Altera and NEC in Japan. The tool was developed and continues to evolve in consultation with Altera, the California-based FPGA manufacturer with a large R&D arm in Toronto.

“Coming out of second year, I knew all that theory but I didn’t know how to apply other words, the way it adds more people to the assembly line and assigns them tasks. He’s designed many of the self-test features of the tool that make it robust, easy to use and modify. “I feel like it’s important to contribute back and release something,” says Canis.

Choi knew he wanted to concentrate on high-level synthesis for his graduate work. After completing his MASCi with Professors Brown and Anderson, he applied to several American schools for his Ph.D but “nothing was as interesting as what we were doing here, so I stayed,” he recalls. The direct connection to industry was a big plus, too. “That was motivating for us because we know that people are using it, we know that what we’re doing now will make a difference,” says Choi. “It helps us do a proper job because people are going to see our code.” Choi’s not the only student compelled to stick with the project: recently Lanny Lian, a veteran from the summer of 2012, rejoined the team to begin a master’s degree. For just started his Ph.D full time, while maintaining a part-time role at Altera.

The group sits down three times a week to bounce ideas off each other, get input from Professors Anderson and Brown, and hear from Tomasz Czajkowski, a design engineer at Altera and former grad student of Brown’s who consults on the project. “The undergrads are full-fledged members of the team, contributing to future releases of the tool and helping to produce publishable research results,” says Professor Anderson. “Both the grad students and I are truly impressed by their capabilities.”

Emily Miao grew up in Richmond, B.C., but moved to Delaware to attend a highly competitive high school known for excellence in math and science. “I’ve always loved math and science, even when I was little,” she says. She chose U of T for the strength of its ECE program, and knew Cai got a chance to put another one of his hobbies — a love of games — to good use toward the end of the summer. In collaboration with the team, Cai designed an algorithm for playing the Tetris-like game Blokus — an algorithm to be synthesized into FPGA hardware by LegUp. Teams from around the world submitted FPGA-based solutions to compete in a massive Blokus tournament at the International Conference on Field-Programmable Technology this winter in Kyoto, Japan. The tournament would be the ﬁrst chance for LegUp-synthesized FPGA hardware to go head-to-head against human-designed hardware, still the industry gold standard, in a competitive gaming scenario. It’s not the summer project Cai planned to take on, but he’s thrilled it came his way. Says Cai, “Everyone loves games, right?”

“It’s definitely more of a hobby for me,” says Cai. “But it’s something I enjoy doing, something I think could be interesting.” In the summer project Cai planned to take on, he wanted to see what it’s like in this environment, kind of like you’re going to grad school,” says Miao. “This project is unique because you really get exposed to this industrial network as well as the academic network.”

Cai had already had a taste of summer research after his ﬁrst year when he worked for a professor in Materials Science & Engineering, but wanted to see what it’s like in ECE was like. “Jason made his research seem interesting — like he really enjoyed it. And the idea of making hardware out of software was pretty cool,” says Cai. In his spare time Cai is teaching himself Java, and he enrolled in a singing competition. “It’s deﬁnitely more of a hobby for me,” says Cai.

The undergrads are full-fledged members of the team, contributing to future releases of the tool and helping to produce publishable research results.”
Discoveries are Made

Jeff Cassidy is all about exploration — both intellectual and physical. The Hamilton, Ontario native has just completed his master’s thesis, co-supervised by Professor Vaughn Betz of The Edward S. Rogers Sr. Department of Electrical & Computer Engineering and Professor Lothar Lilge of the Ontario Cancer Institute and U of T’s Department of Medical Biophysics. In his spare time he teaches sailing, goes heli-skiing, canoes, and plays squash once a week with the guys in his lab. This fall Cassidy began work toward his PhD, driving his project’s focus toward developing hardware for faster and more power-efficient computing systems, including an energy-efficient, reconfigurable computing platform that he calls SOSCIP. Cassidy will program a part of SOSCIP to run his photon-predicting application, and tailor hardware to the new system. His is one of a few projects to have access to the SOSCIP’s agile computing platform.

Cassidy is currently designing the FPGA bitstream that will program the SOSCIP machine to simulate light propagation. With close collaboration with researchers at Princess Margaret Hospital, a leading cancer research institution located in Toronto, it may be possible to see PDT for head and neck cancers begin clinical trials in a matter of just a few years. “The goal is to advance this towards pre-clinical and clinical trials within the timeframe of my PhD,” says Cassidy. “That was one of the things that kept me on here, having something that may treat real people within four years.”

It’s a goal that means a lot to him personally. “Like anyone, I’ve had a lot of family and friends affected by cancer. My Uncle Andy had a recurrence of throat cancer and ultimately died. So I like that with this work, there’s a sense that you’re making a material difference in someone’s quality of life.”

He never planned to have a career in medicine. Always talented at math and science, Cassidy earned his undergraduate degree in Electrical Engineering from McGill University in 2006. From there he took a job at WESCAM in Burlington, Ontario where he’d completed internships while at McGill, and developed a digital video processing unit for their airborne military surveillance cameras. He then made the jump to finance, spending a year and a half at Scotiabank and then another year with Manulife. While working in finance, he studied and passed all three of his Chartered Financial Analyst exams. “Engineers get hired into finance because of programming and mathematical skills,” says Cassidy. “Quantitative modelling skills open doors everywhere.”

But after a period learning how financial institutions work from the inside out, Cassidy started to feel his explorer’s itch acting up. “I missed the challenge of designing large, complex systems,” he recalls. In December 2010 he began working on treating cancer. I’ve done financial modelling, image processing,” says Cassidy. “What field of endeavour or business doesn’t rely on computing?” For example, mapping the genome, searching for the Higgs Boson, commerce, data mining — all this stuff is stuff you can get involved in as a computer engineer. And not just one of those — you can hop between them because you have this portable skillset.”

Today Cassidy is completely focused on driving his project toward clinical trials, one step at a time. But with his engineering training, countless unexplored paths lie in his future.
A flock of birds sits on the steep slope of a church roof. Sparked by some invisible signal, the birds take off in unison, rising into the sky, banking a sharp left, diving unison, rising into the sky, as birds — Professor Kundur wants to apply birds’ robust flocking behaviour to modelling framework that encompassed the many aspects of cyber-physical interactions, which can allow additional parties to exploit weaknesses. Therefore, it’s imperative that we study the impact of integrating advanced communications and computing to power system security,” says Professor Kundur. A system is only as secure as its weakest link, and it takes a little bit of cunning on Professor Kundur’s part to think, “If I were a villain, what would I really want to do?” But what does all that have to do with birds? Professor Kundur and her lab have borrowed from the biological world to model robust energy grids, capable of elegantly handling failure or chaos. “It’s exciting when you see analogies,” she says. Imagine a collection of synchronous generators contributing energy to the grid. If a tree falls across a set of high-voltage transmission lines, a major route for energy distribution is cut off, and generators can fall out of sync. All of a sudden one part of the grid is not getting enough power, while other sections get too much. This has the potential to significantly disrupt power flow, leaving it acutely vulnerable to another failure. Think of the individual generators as birds — Professor Kundur wants to apply birds’ robust flocking behaviour to generators, letting the Smart Grid store and redistribute energy around a metaphorical obstacle resulting from the tree fault, much like birds avoid the church spire. The generators can then re-sync themselves and stabilize the system, skipping the brownouts or blackouts that typically result from a system under duress.

Born and raised in Toronto, Professor Kundur is herself a three-time ECE graduate, earning a BASc in 1990, a MASc in 1995 and a PhD in 1999. After completing her doctoral studies in 1999, she worked for several years at the University of Toronto, and in 2003 to join the faculty at Texas A&M University. She returned to U of T in August 2012, bringing three adventurous graduate students and a postdoctoral researcher with her.

It’s not easy to find models that accurately describe both the physical world and virtual world while elegantly describing their complex interactions. “The Holy Grail in this area is if you could develop a modelling framework to help power utilities identify weaknesses and prioritize protection strategies.

A little bit of cunning on Professor Kundur’s part to think, “If I were a villain, what would I really want to do?”

But what does all that have to do with birds? Professor Kundur and her lab have borrowed from the biological world to model robust energy grids, capable of elegantly handling failure or chaos. “It’s exciting when you see analogies,” she says. Imagine a collection of synchronous generators contributing energy to the grid. If a tree falls across a set of high-voltage transmission lines, a major route for energy distribution is cut off, and generators can fall out of sync. All of a sudden one part of the grid is not getting enough power, while other sections get too much. This has the potential to significantly disrupt power flow, leaving it acutely vulnerable to another failure. Think of the individual generators as birds — Professor Kundur wants to apply birds’ robust flocking behaviour to generators, letting the Smart Grid store and redistribute energy around a metaphorical obstacle resulting from the tree fault, much like birds avoid the church spire. The generators can then re-sync themselves and stabilize the system, skipping the brownouts or blackouts that typically result from a system under duress.

Discoveries are Made in Unexpected Places

Professor Deepa Kundur: Imagination in Engineering

Bridging the gap between the visceral present and the visionary future is what Professor Kundur does best, using imagination, open-mindedness and creative design. “What we aim to do is find elegant analogies that highlight the critical aspects of practical systems,” she says. “So when we can find a metaphor that very beautifully meshes with a real-life situation and it inspires a new way of thinking, that’s just a wonderful thrill.”
from the antilock-brakes in your car, to the central heating in your house, to the high-tech Canadarm on the International Space Station. “Control systems are what make devices smart, to the extent that they need to be,” says Professor Bruce Francis. Francis began working on theoretical robotics problems around 2002 after Tim Barfoot, now a professor in the University of Toronto Institute for Aerospace Studies (UTIAS), took one of Professor Francis’s graduate courses and invited him to visit the Institute.

There Professor Francis saw penguin-like robots shuffling around on the floor and thought, “That’s interesting, I could work on that.”

One of his earlier projects, a collaboration with Professors Maggiore and Broucke, asked how robots, mathematically modelled as points or unicycles in the plane, could move to find one another, or rendezvous. The robots can see a few of the others but not the whole group. One of their solutions is called cyclic pursuit — each robot will pursue the next at a fixed speed, until they eventually arrive at a common point. More recently Professor Francis has worked with Professor Barfoot on control algorithms for wheeled vehicles in convoy, getting unmanned pursuit vehicles to faithfully follow a route set out by a human-driven lead vehicle. It’s one of many flourishing collaborations between ECE and UTIAS.

Historically, control theory hasn’t been the flashiest discipline as most of its action goes on under the hood. But students can get a sense of what we’re facing, think back to the early 1990s when personal computers started appearing in regular homes. They were handy for word processing and some games, but the average user couldn’t do much else. Fast-forward 20 years, and most people can’t imagine how they’d organize photos, choose a restaurant or complete their banking without a laptop, tablet or smartphone. We’re about to see the same explosive proliferation and adoption of smart robotic devices, predicts Professor Broucke. And just like the early days of computers, we can’t yet conceive of all the things we’ll need them to do.

One thing we do know: control theory will be at the heart of the robots revolution — or more accurately, at its head. “We control theorists design the brain of the system,” says Professor Mandfredi Maggiore. Most human-made devices need controllers, fixed speed, until they eventually arrive at a common point. More recently Professor Francis has worked with Professor Barfoot on control algorithms for wheeled vehicles in convoy, getting unmanned pursuit vehicles to faithfully follow a route set out by a human-driven lead vehicle. It’s one of many flourishing collaborations between ECE and UTIAS.

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“The world needs even more well-rounded engineers now — that evolution is happening in ECE and I want to be part of it.”

Sohayla Praysner
ElecE 8T6

“I like being part of a team of educators and researchers enabling the next wave of transformation in communications, healthcare, business productivity, everything. The students we’re training are going to make that happen.”

Professor Vaughn Betz
ECE PhD 9T8

Sohayla Praysner chairs the Skule Society Committee at the Faculty of Applied Science & Engineering, a community of donors whose leadership helps our Faculty maintain its position as a global leader in training engineers for the future. Getting involved in Skule Society is just one way to support our Boundless campaign.

As a PhD student, Vaughn Betz co-founded a start-up that was acquired by a large chip-manufacturing company. After 13 years working in industry he returned to ECE as a professor — now he teaches the next generation of engineers how to translate their knowledge to the business world. Your support helps our faculty members bring the best of their innovative research into the classroom.

To find out more, contact joannaf@ecf.utoronto.ca, 416-978-7270 or donate.utoronto.ca/engineering
Our Community

The Edward S. Rogers Sr. Department of Electrical & Computer Engineering at the University of Toronto is fortunate to have valuable, long-standing partnerships with visionary corporations, foundations, alumni and friends that guide and support the advancement of research and teaching in the country’s largest ECE department. We invite collaborations with both individuals and industry to help ensure that our research remains relevant, and to create avenues for significant economic and social contributions to Canada and throughout the world.

Our industry partnerships are multi-faceted and include more than 60 industry funders and collaborators. As you’ll read in this section, close partnerships with companies like TELUS let our researchers apply their work to solve real-world issues. Corporations such as Altera and IBM provide valuable opportunities for our students through work-experience programs such as the Professional Experience Year (PEY), and support the educational and research missions of the department through grants and philanthropic support.

ECE is fortunate to have more than 10,800 alumni located around the world — from Toronto to Taipei, San Jose to Singapore. Our alumni have risen to prominence in a wide variety of fields, including business and academia — read more in our alumni profile of brothers Alex and Anthony Grbic, later in this issue. We are committed to staying in touch with this group through events such as our Alumni Lecture & Networking Reception, Fourth-Year Reception, which unites graduating students with members of the alumni community, and Spring Reunion, an opportunity for ECE grads from all classes to return to campus to socialize, tour our laboratories and share memories.

We regularly share alumni news on the front page of the ECE website, www.ece.utoronto.ca as well as through our social media channels on Facebook, Twitter and LinkedIn. If you have a piece of news you’d like to share with us, we’d love to hear from you — please send a note to Mant Mitchell, our senior communications officer, at mant.mitchell@utoronto.ca.

Our industry partners enjoy an effective multiplier of up to 5x their spending on joint research projects with ECE. Cash and in-kind contributions by our industry partners can be used to leverage additional cash investments from the provincial and federal governments, and from the University.

Board of Advisors

This year ECE formed its Alumni Board of Advisors, a diverse and hugely accomplished group of graduates and industry leaders. The Board meets throughout the year to advise the department on its advancement activities and strategic direction. Our Board members are:

Alan Boyce

Alan Boyce is a senior management consultant, executive and entrepreneur with more than 35 years of experience in consulting, technology, management and training. He is a registered Professional Engineer in Ontario, a certified Project Management Professional, holds a Master of Business Administration degree, and is a Certified Management Consultant. Mr. Boyce is the Chief Executive Officer of SOMOS Consulting Group, a growing consulting and training company with practices in project management, information technology, CRM, supply chain management, and benefits management systems. Alan built SOMOS from its conception in 1991 to the present day and oversaw the sale of the company in 2013 to SEB Inc. (TSXV:SEB). An alumnus of The Edward S. Rogers Sr. Department of Electrical & Computer Engineering, Mr. Boyce graduated in the class of 78.

John East

John East retired from Actel Corporation (a public company) in November 2010 in conjunction with the transaction in which Actel was purchased by Micronsemi Corporation. He had served as the CEO of Actel for 22 years at the time of his retirement. Previously, he was a senior vice president of AMD, where he was responsible for the Logic Products Group. Prior to that, Mr. East held various engineering, marketing, and management positions at Raytheon Semiconductor and Fairchild Semiconductor. In the past he has served on the boards of directors of Adaptec and Zohreh (both public companies), and MOC and Single Chip Systems (both private companies). He currently serves on the board of directors of Alacritech — a private high-tech company involved in the data storage market — and Pericom — a public fabless semiconductor company. He holds a BS in Electrical Engineering and an MBA from the University of California, Berkeley. He has lived in Saratoga with his wife Pam for 40 years.

Dr. Alex Grbic

Dr. Alex Grbic is a Product Marketing Director at Altera, responsible for Software and IP products. At Altera, Dr. Grbic has held management positions in the Software and IP R&D organization, where he headed up external memory interfaces IP development, performance analysis of Altera’s products and work on visualization/debug tools. More recently, he was Director of Applications Engineering, where he led customer support initiatives, including early adoption of new products, and technical collaboration. Dr. Grbic holds a PhD in Computer Engineering from the University of Toronto.

Catherine Lacavera

Catherine Lacavera joined Google in 2005. As Director of Litigation, she manages a team of over 20 intellectual property attorneys and technical advisors. She oversees a docket of more than 200 pending patent and other intellectual property litigation matters both within and outside of the United States, including the Vacom and other copyright litigation against YouTube, and the Apple, Microsoft and Oracle copyright and patent litigation directed at Android. Ms. Lacavera also advises on complex licenses and acquisitions, both within and outside the litigation context, including the acquisition of Motorola Mobility for $12.5 billion. In 2013, she was named one of Fortune’s 40 Under 40, one of the most innovative in-house counsel by the Daily Journal, and a Rising Star in the Best Bay Area Corporate Counsel Awards. In 2012, she was recognized by the Silicon Valley Business Journal as one of the top 40 under 40 for significant contributions to the community. Prior to joining Google, Ms. Lacavera practiced patent litigation in New York City at a large global law firm. She graduated from Computer Engineering in the class of 97 and holds an MBA and law degree, all from University of Toronto.

Dr. Alex Shubat

Dr. Alex Shubat has more than 25 years of experience in design, management and executive roles in the technology industry. He previously co-founded Virage Logic in 1996, and served as the company’s President and CEO until September 2010, when the company was acquired by Synopsys. During his tenure as CEO, the company doubled its revenues, increased profitability, gained market share through both organic and inorganic product expansion, completed three acquisitions, and expanded its global footprint. Prior to co-founding Virage Logic, he served as Director of Engineering at WaferScale Integration, a provider of programmable microcontroller peripherals (subsequently acquired by ST). During his 10-year career at WaferScale Integration, he managed various groups including the application-specific integrated circuit and high-speed memory groups. He holds 27 patents and has contributed to more than 25 publications. Dr. Shubat earned an Executive MBA from Stanford University, a BASc and an MASc in Electrical Engineering from the University of Toronto, and a PhD in Electrical Engineering from Santa Clara University. Dr. Shubat currently serves as the CEO of Goji Food Solutions, Inc.
Anahita Panthaky (ECE 1T0) began volunteering with ECE as a student, and since graduating in 2010 continues to serve at alumni and recruitment events. Her active and enthusiastic support has directly contributed to the department’s efforts to recruit the most promising candidates from Ontario, Canada and around the world.

Warren Brown (ECE 0T3) has been serving ECE for more than 60 years. Brown helped organize and operate the department’s Lunch & Learn Speaker Series, a gathering of classmates and experts that has been running for nearly 40 years.

Michael Branch, (CompE 0T1), received a Young Engineer Award from the Ontario Society of Professional Engineers (OSPE) and Professional Engineers Ontario (PEO). These Ontario Professional Engineers Awards recognize engineering excellence and community service. Branch is the founder and CEO of Inovex Inc., a web and mobile software firm specializing in products and services for the healthcare and energy sectors, and creators of Maps4 – a new internationally awarded cloud-based mapping and business intelligence platform. He has been instrumental in developing Inovex’s lineup of secure healthcare data collection and decision-making tools for physicians and public health policy drivers in Ontario. A committed volunteer within and outside the engineering community, Branch served as President of the University of Toronto Engineering Alumni Association. He also serves as a Board Member of Streetwise Actors and a member of the Haltech Regional Innovation Centre.

ECE’s Centre for Applied Power Electronics (CAPE) has joined with Toronto Hydro and industry partners eCAMION and Korea-based Dow Kokam to install the world’s first community-based power storage unit. The unit is tied into the Toronto Hydro grid and consists of a 250-kW battery system that can power an entire street for one hour if the electrical system fails.

ECE’s Boundless Potential

Our individual and corporate partnerships are of vital importance to us and enable today’s scholars and tomorrow’s engineering leaders to make groundbreaking discoveries and advance knowledge in every area of electrical and computer engineering. Ongoing engagement, support and collaboration ensure ECE’s ability to maintain its leadership position among the world’s top authorities on electrical and computer engineering, and to build a global society of boundless innovation, creativity and economic development.

Individual donations from alumni and friends ensure that engineering scholars can focus their time and efforts on developing new technological breakthroughs, rather than worrying about financial constraints. There are many different ways to support ECE projects and initiatives. Skule Society is a special community of alumni and friends who demonstrate leadership with annual gifts of $1,000 or more to the department. The creation of endowed chairs and professorships, graduate fellowships, and undergraduate scholarships are also important elements to Engineering’s $300-million component of Boundless: The Campaign for the University of Toronto.

For further information on how you can support The Edward S. Rogers Sr. Department of Electrical & Computer Engineering, please contact Joanna Forbes at joannaf@ece.utoronto.ca.

CAPE & eCAMION Make Grid a Little Smarter

ECE’s Centre for Applied Power Electronics (CAPE) has joined with Toronto Hydro and industry partners eCAMION and Korea-based Dow Kokam to install the world’s first community-based power storage unit. The unit is tied into the Toronto Hydro grid and consists of a 250-kW battery system that can power an entire street for one hour if the electrical system fails.

A team led by Professor Reza Iravani developed the algorithms and software that integrates the power unit into the grid and provides control and operational needs of the battery system according to Toronto Hydro’s requirements.

Pictured above: Professor Farid Najm and Professor Reza Iravani with Bal Gosai, federal Minister of State (Sport), who announced that Professor Iravani’s Centre for Applied Power Electronics would receive a $500,000 grant for circuit breaker technology for fast protection or isolation of battery storage systems.

Get in touch! Stay current!

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Electrical & Computer Engineering at U of T

Electrical & Computer Engineering Alumni, U of T

10,805

Number of ECE alumni worldwide
It’s a Wednesday morning and you’re finishing your breakfast cereal while streaming Futurama on Netflix.

You take a last sip of your coffee, grab your tablet, and rush out the door with a chuckle. As you leave your house the show keeps rolling, your device making a seamless transition from your home WiFi connection to your service provider’s LTE.

Down into the subway, then up 60 stories to your office in a glass skyscraper, you arrive at your desk just in time to catch the last punch line.

Sound too good to be true? Not for long — that kind of super data-rate mobile service may be reality soon. Here’s why.

As you sit at your desk just in time to catch the last punch line, you are about to discover the collaboration between TELUS and Professor Ibrahim Gedeon.

It all started when Dr. Adam Tenenbaum, Senior RAN Design Specialist, and Dr. Ivo Maljević, both ECE alumni themselves, were approached by TELUS’ Chief Technology Officer, who is a big believer in forging stronger ties with the academic community. Dr. Gedeon holds firm to his philosophy that a company should cultivate a healthy ecosystem by pursuing harmonized growth and development through collaboration with academia, business, government and industry. As demand for higher data-rate services pushes TELUS and its competitors to the limits of their carrying capacity, it’s more important than ever to invent new strategies to maximize performance out of a system that is confined by limited spectrum bandwidth. Gedeon "is the driving force behind TELUS’ funding for university research," says Dr. Adam Tenenbaum, a Radio Access Network (RAN) Design Specialist for TELUS and one of the collaboration’s coordinators. "It’s about developing good engineering resources to support the Canadian market."

Think of the wireless world like a highway — perhaps Toronto’s heavily trafficked Highway 401. Lanes of the highway correspond to sections of spectrum bandwidth, dedicated to different services — some for traditional television transmission, some for AM radio, and some for FM radio that you listen to in your car. The lanes dedicated to voice and data transmission for mobile service providers are further subdivided, allowing TELUS and its competitors a fixed number of lanes each. When you sign up with TELUS, you add to the traffic in its lanes. Like the 401, the system was set up long ago with no expectation of the intense level of traffic it now carries. With mobile data demand exploding, the lanes are now clogged with users wanting high-speed all the time, and traffic jams ensue.

But it’s not so easy to add more lanes. "We’re talking about billions of dollars to buy bandwidth," says Professor Adve. "That’s why TELUS has turned to ECE at U of T — in hopes of finding ways to get more people on the wireless highway without congestion or conflict."

Enter TELUS’ Dr. Adam Tenenbaum, Senior RAN Design Specialist and Dr. Ivo Maljević, both ECE alumni themselves. It’s their job to scour the country for potential researchers and development solutions to TELUS’ real-world challenges, and to support projects likely to have future applications for their company. "We’ve selected professors that are at the cutting edge of research," says Dr. Maljević, a Senior RAN Design Specialist. "We strongly believe that the work they do benefits both TELUS and Canada."

The association dates back to a partnership between TELUS and Professor Sousa’s group in 2004, and in 2011 when TELUS joined the Smart Applications on Virtual Infrastructure (SAVI) network, an NSERC Strategic Network led by Professor Leon-Garcia. Professor Leon-Garcia then began working with TELUS on a wireless network quality of service project, and Maljević and Tenenbaum expanded into wireless research with Professors Adve and Sousa. Industry investment has been the key to the partnership’s success — the funds invested by TELUS are augmented by an NSERC Collaborative Research and Development grant, designed specifically to compound the value of connections between universities and Canadian industry.

“Everyone knows when you use Internet on your desktop computer, it’s much faster than using it on your mobile device,” says Professor Sousa. “Our goal is to come up with really new ways to close the gap between using your mobile device or desktop computer.” The solution involves reconfiguring the existing network infrastructure to fit service holes between big long-range cell phone towers, called base stations, and smaller base stations, called small cells, to handle calls and data demand across many small geographic zones.

This mix of base stations and small cells is known as a heterogeneous network, or HetNet, and Professor Sousa’s group has been studying these new architectures for over a decade. It’s his vision to design the next generation of autonomous infrastructure wireless networks. “We come up with methodologies to deploy small cells in such a way as to manage interference,” says Professor Sousa. “It’s like setting up a party in a room with many people — it’s hard to carry on a conversation over the noise. Sousa

Discoveries are Made while Looking to the Future

TELUS & ECE: Industry Partnership Fuels Innovation

It works on arranging the party-goers so the loud-talking base stations and soft-spoken small cells can be heard simultaneously. He also tries to find the best ways to phase out old technologies, designed primarily for voice calls, to make room for data-intensive 4G and LTE service, without causing major disruptions.

Professor Adve’s project runs jointly with Professor Andrew Eckford of York University. Their research focuses on resource allocation in HetNets — determining how much bandwidth and how much power each small cell needs to maximize service while minimizing consumption. The smaller cells are to the user, the more effectively they can recycle bandwidth as that person moves from one to the next, and the handset should be invisible. Professor Adve is looking toward a future of streaming live video in the subway, or Facetime chatting at the top of an office tower. “You should be able to use anything you want, wherever you want. I think that would be a long-term goal,” says Professor Adve. “And not just you — hundreds of people.”

Professor Adve is excited about the possibility of incorporating real traffic data into his models, further closing the gap between academic theory and practical application. “They’re encouraging us to look at very forward-thinking questions,” he says. “We’ve already had quite a few productive discussions on this.” And both sides look forward to many more.
Shared Commitment

Alex and Tony Grbic: ECE Alumni on Top

Alex and Tony Grbic are ECE Alumni on Top for Altera and the newest member of ECE’s Board of Advisors, and Tony is an associate professor at University of Michigan. Both Alex and Tony are triple graduates of The Edward S. Rogers Sr. Department of Electrical & Computer Engineering, each earning undergraduate, master’s and PhD degrees at University of Toronto. But look past the parallel credentials and it’s clear that each has carved a career path as unique as it is extraordinary — one to the top of the industry, the other to the top of academia.

“We’re both ECE grads, but we were in pretty much opposite disciplines within the department,” says Alex. “I’m into the computer hardware and digital world, and he’s into electromagnetics, math and all that ‘fun stuff.’ So we’re in the same department, but attracted to opposite ends of the spectrum.”

Sir John Pendry, one of the world’s leading theoretical physicists and the man largely responsible for inventing the field of metamaterials, was visiting UF and Professor Eleftheriades invited Tony to join the pair for dinner. “I was ecstatic, I’ll never forget that dinner for the rest of my life,” says Tony. “The simple gesture of inviting me to dinner with such a prominent researcher kind of meant the world to me.”

After completing his PhD with Professor Eleftheriades, he and his wife Ana moved to Ann Arbor where Tony joined the faculty at University of Michigan in early 2006. Pendry wasn’t the only high-profile figure starting to enjoy academic research. But Alex wasn’t my guidance counsellor in picking courses!” jokes Tony. “I took some advice from him in undergrad — he convinced me to take an operating systems course in my senior year and it nearly killed me.”

Born and raised in Brampton, Ontario, Alex and Tony showed strong interest in technology and aptitude for science and math. When it came time for Alex, the elder brother, to pick a school, “University of Toronto was clearly a favourite,” he says. Four years later, Tony considered the program’s ranking against Waterloo’s and McMaster’s, and followed suit. (Skule truly runs in the family blood — their younger sister, Mary Vanda Grbic, graduated from Chemical Engineering in 2007.)

Now widely recognized as a leading researcher in the fields of antennas, microwave circuits and metamaterials, Tony’s focus revealed itself gradually. “I wasn’t sure in undergrad what I wanted to study until I took the Fields and Waves course taught by Professor Sergi Dmitrovsky,” he remembers. “That sparked my interest in electromagnetics.”

Many years and thousands of students later, Professor Dmitrovsky still remembers teaching Tony. “His dominant feature was a rich imagination, and an ability to accept new concepts,” he says. New concepts were flying when Tony launched into his master’s in applied electromagnetics with Professor George Eleftheriades. “Tony was an exceptional student,” says Professor Eleftheriades. “He has a very positive personality, and he’s very determined. I was really blessed to work with Tony.” Metamaterials was then an emerging area, generating a lot of excitement. Their group published some of the first papers in the field and Tony was starting to enjoy academic research. But one particular evening still stands out to him.

For Altera and the newest member of ECE’s Board of Advisors, and Tony is an associate professor at University of Michigan. Both Alex and Tony are triple graduates of The Edward S. Rogers Sr. Department of Electrical & Computer Engineering, each earning undergraduate, master’s and PhD degrees at University of Toronto. But look past the parallel credentials and it’s clear that each has carved a career path as unique as it is extraordinary — one to the top of the industry, the other to the top of academia.

“If you want to know about Alex Grbic’s career highlights, ask his brother Anthony. And if you’d like to hear about Tony’s accomplishments, Alex will fill you in.

Each too humble to mention his own successes, the Grbic brothers have good reason to be proud of one another — Alex is currently director of product marketing for Altera and the newest member of ECE’s Board of Advisors, and Tony is an associate professor at University of Michigan. Both Alex and Tony are triple graduates of The Edward S. Rogers Sr. Department of Electrical & Computer Engineering, each earning undergraduate, master’s and PhD degrees at University of Toronto. But look past the parallel credentials and it’s clear that each has carved a career path as unique as it is extraordinary — one to the top of the industry, the other to the top of academia.

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Corporate Partners

Name: Yoley Li
PEY Placement: Ontario Power Generation
Title: Engineering intern - Plant Computers section, Computer and Control Design department
Experience: "Working in an industry where safety is the number one goal has changed my attitude towards delivering work. It makes me realize that even as an intern, my work could potentially impact many other people and there is no room for mistakes. It is rewarding to see my name appearing on the milestone completion form. Sometimes the staff forget that I'm an intern because I am working on projects just like any other full-time employee."

Name: Yu (Jack) Luo
PEY Placement: IBM
Title: Continuous Engineering - DB2 Kernel
Experience: "This position features flexible work hours, good benefits and competitive pay. But most importantly, it confirmed my future career path of being a computer engineer."

2013–2014
ECE PEY students hired by:

Name: Yu (Jack) Luo
PEY Placement: IBM
Title: Continuous Engineering - DB2 Kernel
Experience: "This position features flexible work hours, good benefits and competitive pay. But most importantly, it confirmed my future career path of being a computer engineer."

Name: Ahsan Sardar
PEY Placement: Qualcomm
Title: Linux Software Engineer
Experience: "I chose Qualcomm for work-life balance, and the fact that Qualcomm is a leading tech company with a bright future."

Name: Piyush Gupta
PEY Placement: Multimedia Software Engineer
Title: "One of the most innovative and prestigious companies to work for, Qualcomm offers myriad opportunities to turn my ideas into reality."
Directory
Colour-Coded Legend

Each research category has a corresponding colour. Search by colour to locate the lead researcher and project details.

- **Communications**
  - Communications Equipment
  - Communication Systems and Services: Planning, Organization, Services
  - Communications Technologies: Satellites, Radar

- **Computers**
  - Computer Communications
  - Computer Software/Hardware

- **Engineering/Sciences**
  - Aerospace
  - Electrical and Electronic Machinery, including Computer Hardware
  - Ground: Road and Rail
  - Instrumentation Technology and Equipment, Computer Hardware
  - Materials Sciences
  - Mathematical Sciences
  - Physical Sciences

- **Information Technology**
  - Information and Communications Services
  - Information, Computer and Communication Technologies
  - Information Systems and Technology

- **Energy**
  - Energy Resources: Production, Exploration, Processing, Distribution and Use
  - Energy Storage and Conversion
  - Energy Efficiency
  - Alternative Energy Resources
  - Electrical Energy

- **Life Sciences**
  - Advancement of Knowledge
  - Biomedical Engineering
  - Human Health
  - Life Sciences
  - Life Sciences, including Biotechnology
  - Medical Equipment and Apparatus

Quick-Search by Colour-Coded Listing

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In the past few years, we have seen an exponential increase in the number of videos and images that have been recorded and placed on the internet. Smart mobile phones (Blackberry, iPhone, etc.) now enable seamless recording, transmission and sharing of videos in near-real time. Whereas just two decades ago there were a few video broadcasters and publishers, today there are millions, if not billions, of video broadcasters and online publishers. With all this visual content, how do we find what we want? How do we categorize the content? How do we develop search engines that bring order to visual content just as text-based search engines (Google, Bing, etc.) brought order to the textual web? With videos and images, there are of course certain tags manually entered by users that define and categorize the videos. However, the 15–15 words that usually accompany a video or image can hardly describe the entire content of the video and at best help to generally categorize the video or mention a specific note regarding it. In fact, the vast amount of visual information online is untagged and inadequately described and as a result is difficult if not impossible to find. Finding all images and videos is but one problem. The appropriate categorization of visual content can result in more appropriate contextual advertisements (leading to better monetization of visual web/mobile sites). It can help in finding duplicate versions of the same video or image (which is useful for copyright detection, among other applications). It can also help identify the important parts of a video segment or the most content-rich section of an image (which is useful for compressing videos and intelligently resizing images for mobile devices). The more information we can extract automatically from images and videos, the more we can address a range of practical problems (including better search, buffer (and more contextual) information, computer and communication technologies, information technology, information and communications services, information systems and technology, medical equipment and apparatus, advancement of knowledge, life sciences, medical equipment and apparatus, advanced engineering, life sciences, including biotechnology, human health, biomedicine, computer science, and electrical engineering).
Alpha-listing by Lead Researcher

**COMPILER SUPPORT FOR GP-GPU PROGRAMMING**

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<tr>
<td>Adve, Raviraj</td>
<td>Adaptive Signal Processing for Wireless Communications and Radar Systems</td>
<td>Green</td>
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Soft processors have gained popularity as a means of implementing general purpose computations on Field Programmable Gate Arrays (FPGAs) using the familiar sequential programming model. However, soft processors are slow compared to dedicated FPGA designs. In this project, we explore the dynamic acceleration of soft processors using traces. Our approach is to execute a program on a soft processor, detect at runtime hot spots of execution (i.e., traces) in the program, and then dynamically synthesize circuits on an FPGA to speed up the execution of those traces. This approach has the advantage of leveraging the considerable resources on an FPGA to match the dynamic characteristics of an application in a transparent way. However, it faces several challenges. They include: (1) the efficient detection of traces; (2) the quick synthesis of a trace at runtime (the use of traditional CAD tools is prohibitive); and (3) the dynamic reconfiguration of the FPGA to realize the synthesized trace circuit at runtime. Our goal is to address those challenges through a novel overlay architecture that we refer to as the Virtual Dynamically Reconfigurable FPGA (VDFPGA). We further use a trace synthesis approach that exploits the fact that traces are short, straight-line segments of code, which makes them more amenable to analysis and optimization at run time.

**COMPUTER HARDWARE: APPLICATIONS, TOOLS, ARCHITECTURE, CIRCUITS FOR PROGRAMMABLE LOGIC**

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<td>Anderson, Jason</td>
<td>A Self-Profiling Adaptive Processor: High-Level Hardware Synthesis</td>
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We are building a self-accelerating adaptive processor by modifying the architecture of a standard processor to create the ability to profile the execution of its own code. Using this profiling ability, our unique processor will be able to identify sections of its code that need optimization. Specifically, the profiling results will drive the selection of program code segments to be re-targeted to custom hardware from their original high-level language implementation. Co-RTL synthesis will be used, with the RTL subsequently compiled using standard back-end tools. Once the hardware ‘compute acceleration’ is available, the program binary will be modified to access the accelerators accordingly. Programmable logic devices, such as field-programmable gate arrays (FPGAs), are ideal for implementing and evaluating designs for such adaptive processors, as FPGAs can be configured in milliseconds to implement any digital circuit. The reconfigurability of FPGAs also permits functionality to evolve over time, based on application needs.

**AMZI, CRISTOIANA**

www.ece.utoronto.ca/~amziamaz.png

The economy has been transformed by the delivery of web services over the Internet in the past three decades. Behind the scenes of web-based service delivery technologies are large-scale, complex information systems. These information systems consist of thousands of servers, which store client data in a consistent and persistent manner and are multiplexed across several applications. Many aspects of content delivery still currently depend on manual fine-tuning and troubleshooting by humans. As a result, the service provider is strapped with huge human administrator costs for performance debugging, resource allocation to applications and infrastructure configuration adjustments. This is a major impediment to the efficiency of this industry.

**SYSTEM OPTIMIZATION FOR PARALLEL AND DISTRIBUTED SOFTWARE TRANSACTIONAL MEMORY**

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integrated fine-grained locking by acquiring and releasing specific locks on data items. Instead, a cluster-based run-time system automatically detects data races and ensures correct parallel execution for generic parallel programs. Any detected incorrect execution resulting from a data race is rolled back and restarted.

In this project we have focused on reducing the software overhead of run-time memory access tracking and consistency maintenance for Transactional Memory support. We currently support applications with highly dynamic access patterns, such as massively multiplayer games. We have shown that Transactional Memory not only simplifies the programming of these applications, but can also improve performance and scalability compared to the solution obtained by additional locking techniques for code parallelization for the same application.

**ABSTRACT:**

Field-programmable gate arrays (FPGAs) are programmable semiconductor chips that are part of a revolution and poised to be present in every piece of electronic equipment within 10 years. The rapid growth to the efficiency of this industry: limiting reinvestment, research and development. To address this problem, we investigate innovative self-diagnosis and adaptive reconfiguration techniques for scalable and available information systems.

We have designed and developed novel online performance modeling and anomaly detection algorithms and tools that form the basis for self-configuring, self-tuning and self-healing services. We use these techniques in our data centre laboratory to automatically providing quality of service for a range of dynamic content services such as e-commerce, online bidding and massively multi-player games.
now costs tens of millions of dollars and is out of reach for all but a few large companies. FPGAs provide inexpensive access to advanced semiconductor technology, allowing innovation to happen across the spectrum, from small start-ups to large industry to academia.

As they are programmable chips, FPGAs incorporate additional circuitry relative to chips that implement a single fixed function. A consequence is that FPGAs use more power than fixed-function chips and circuitry relative to chips that implement a single fixed function. A consequence is that FPGAs use more power than fixed-function chips and the algorithms that are used to implement circuits in these chips, as well as applications of FPGAs, in addition to my faculty position at the University of Toronto, I maintain an active involvement in the Altera Toronto Technology Centre, where I provide direction for the University Program that is offered by Altera. By combining my involvement in both the University of Toronto and Altera, it has been possible to develop research results that are both interesting from the academic point of view and practical use when implemented in an industrial-quality CAD tool. My current research effort is in the area of CAD flows for FPGAs and specifically in the development of new methods of efficiently compiling high-level language code (such as C code) into circuits that can be implemented in FPGA devices.

**Barsebjian, Berj**

**Bioengineering of the Brain**

This main theme of the research are within the general field of neural engineering and, in particular, bioengineering of the brain. The purpose is to (1) characterize both normal and pathological brain electrical activities and (2) anticipate, then abolish, the pathological electrical activity in the brain, such as epileptic seizures. The approach is to characterize the spatiotemporal relations of the electrical activities in neuronal populations and use cognitive devices to classify the dynamical features of the biological neural networks in the brain. The developed cognitive devices will be implemented as low-power hardware to be incorporated into the biological neural networks in a closed feedback loop. This will enable it to provide implantable devices as therapeutic tools for brain disorders.

**Brown, Stephen**

**CAD and Architecture for FPGAs**

My research is focused on many different aspects of field-programmable gate array technology, including the design of the chip architectures and the algorithms that are used to implement circuits in these devices, as well as applications of FPGAs. In addition to my faculty position at the University of Toronto, I maintain an active involvement in the Altera Toronto Technology Centre, where I provide direction for the University Program that is offered by Altera. By combining my involvement in both the University of Toronto and Altera, it has been possible to develop research results that are both interesting from the academic point of view and practical use when implemented in an industrial-quality CAD tool. My current research effort is in the area of CAD flows for FPGAs and specifically in the development of new methods of efficiently compiling high-level language code (such as C code) into circuits that can be implemented in FPGA devices.

**Broucke, Mireille**

**Control for Complex Specifications**

The field of Systems Control has traditionally been based on steady-state control specifications in the form of stability and tracking. The goal of the project is to develop a theory of control for complex specifications, in particular enabling systematic methods of design and control of the transient phase of a dynamic system. These complex specifications may provide a template for the development of a more unified framework for dealing with systems, typically distributed, which consist of subsystems interacting via a fixed pattern.

**Brotiere, Vincent**

**Improvised FPGA Architecture and CAD**

This fundamentally raises the level of abstraction of communication on the chip, but requires new CAD tools, which we are also developing, to automate this new and different design flow. We also seek to find new algorithms and Computer-Aided Design tools to allow FPGA designs to be completed more quickly and to run at higher speeds and make more efficient use of the chip. In particular, we are looking at how to make highly scalable placement and routing algorithms that can handle the latest chips, which contain billions of transistors, in a reasonable run time.

Finally, we are also investigating new areas in which FPGAs can accelerate computation. A key application in this area we are currently researching is the modelling of photodynamic cancer therapy. By simultaneously activating the pathways of millions of photons in complex human tissue, we seek to determine the best arrangement of fibre optic probes to destroy a tumour (and minimize the exposure of healthy tissue) by activating a photosensitive catalyst only in a local area of the patient’s body.
### Integrated Circuits for Ultra-High-Speed Digital Signal Processing
- **Title**: Ultra-Short-Reach Chip-to-Chip Communication
- **Description**: This project strives to enable the use of robust and reconfigurable digital signal processing (DSP) for our highest-speed communication links. Presently, analog circuitry performs a lot of the key signal processing in multi-Gb/s communication links. Technology trends favor an increasing use of digital circuits and software, but the transition will require significant advances in analog circuits such as analog-to-digital and digital-to-analog converters, as well as signal processing algorithms to automatically calibrate and adapt the links to the conditions of real-world use. Moreover, the power of the circuits must be lowered, in some cases by two orders of magnitude. We develop integrated circuit prototypes of our solutions, demonstrating their potential impact on real-world applications.

### Programming Models and Architectures for High-performance Computing
- **Title**: Reconfigurable and Heterogeneous Computing Architectures
- **Description**: This research investigates approaches to computing using systems of multiple, heterogeneous computing devices. The heterogeneity allows for specialized fabric for special-purpose accelerators that provide low latency access, fewer power dissipation and an appropriate form factor. Current systems use the collected main memory of a cluster of high-end servers for an application that does not need the computation power of such systems. This project exploits the use of Field-Programmable Gate Arrays and novel architectures for building Internet-scale "Big Data" memory systems.

### Improving Energy Efficiency of Energy Conversion Processes
- **Title**: Exploiting Feedback to Architect Streaming Digital Communication Systems For Short Delays and High Reliability
- **Description**: In this project we reexamined the architectural thinking that underlies digital communication systems. This architecture was not designed with the extremely important real-time delay-sensitive streaming and collaborative applications in mind. Applications such as high-end video conferencing, vehicular networks, machine-to-machine communications, and the coordination and fast reconfiguration of distributed systems such as factory robots, demand high-reliability real-time data delivery under strict deadlines. In preliminary work we have shown how to realize astonishing improvements in the reliability of communications at short delays by smartly incorporating receiver-to-sender "feasibility windows" into streaming data systems in this project we will continue to develop the fundamental theory and will also develop the error-correcting codes and decoding algorithms required to implement these ideas in practice. Finally, we will develop a wireless testbed that will consist of a number of wireless devices in which we can prototype our new architecture and algorithms.

### Large Scale Linear Programming Decoding
- **Title**: The Alternating Direction Method of Multipliers
- **Description**: When binary linear error-correcting codes are used over symmetric channels, a relaxed version of the maximum likelihood decoding problem can be stated as a linear program (LP). This LP decoder can be used to decode at bit-error-rates comparable to state-of-the-art belief propagation (BP) decoders, but with significantly stronger theoretical guarantees. However, LP decoding when implemented with standard LP solvers does not easily scale to the block-lengths of modern error correcting codes. In this project we draw on decomposition methods from optimization theory, specifically the Alternating Direction Method of Multipliers (ADMM), to develop efficient distributed algorithms for LP decoding. The key enabling technical result is a nearly linear time algorithm for convex projection onto the parthydopolytope. This allows us to use LP decoding, with all its theoretical guarantees, to decode large-scale error correcting codes efficiently. Our approach has the potential to solve long-standing issues of great industrial importance such as the “error-floor” problem of low density parity-check (LDPC) codes: the existence of which has allowed the adoption of these state-of-the-art codes into applications requiring ultra-low error rates such as magnetic storage.

### Re-Architecting Last Level Caches For Low-Voltage Operation
- **Title**: Power management is a first order priority in the design of modern processors. Dynamic voltage/frequency scaling (DVS), where operating voltage is lowered in step with reduced computational demand, is one of the most successful and widely adopted power reduction techniques. However, increased process variability with technology scaling imposes limits on the minimum operating voltage. Below this minimum large-scale memory structures such as the last-level cache (LLC) cannot be guaranteed to operate reliably. In this project we combine techniques from error-correction coding with architectural insights to redesign LLCs to improve low-voltage performance.
Eletheriadis, George  
Artificial Materials (Metamaterials) from Microwave to Optical Frequencies  

www.ece.utoronto.ca/jgelefth/main.html  

We are developing paradigm-shift metamaterial devices and subsystems and related technologies at RF/microwave and optical frequencies. Metamaterials are artificially structured media with unusual electromagnetic properties. Such properties include negative refractive index, enhanced evanescent waves through resonant amplification and sometimes a negative group velocity. Our vision is to develop metamaterials that can manipulate and control electromagnetic waves, much as conducting wires manipulate the flow of electrons. Both these three-dimensional volumetric and surfaces (metasurfaces) metamaterials are being developed. A recent effort concerns the development of ultrathin metamaterials for stealth manipulation such as refraction (bending of incident plane waves or Gaussian beams), lensing and controlled beam formation. Application areas include super-resolution microscopy and optical microscopy, detection and sensing, advanced hardware for wireless communications, micro- and nanoelectromechanical systems, wireless power transfer, reduction of interference, space technology, radars, defense, solar-cell concentrators, thermophotovoltaics, infrared focal-plane arrays and many more. Examples of devices include small antennae, multi-functional RF/microwave components (including active devices), sub-refraction imaging lenses and probes (even operating in the far field), ultrafast lenses, invisibility cloaks and related “transformation optics” lenses, plasma optical circuits, plasmonic waveguides and nano-antennas. Research includes both experimental work and fundamental theory. Our research is supported by several industrial partners, government agencies and laboratories. Graduates from our group are quite successful in securing faculty positions in academia (e.g., U. Michigan, U. Alberta, MoD, U. Toronto and IBM) and industry (e.g., Apple, AMD, Blackberry, Freescale and Motorola).

Francis, Bruce  
Control Theory and Applications  

www.ese.utoronto.ca/~francis/contact  

1. Distributed robotics theory: We study the mathematical theory of robot formations. The robots are typically modeled as unicities with only onboard sensors and no leaders. The objective is to design local motion strategies so that a team of robots perform a coordinated task, such as forming a circle. (with Professors Mireille Broucke, Manfredi Maggiore and Luca Scardovi)  
2. Applied robotics: Starting in 2007, we conducted an application in collaboration with Defence Research and Development Canada (DRDC), Suffield, Alberta. Motivating this research is a military situation in which a manned vehicle conveys traversable hostile territory to deliver supplies. We designed and tested a vehicle-following system to allow a convoy of full-sized autonomous vehicles with large inter-vehicle spacing to follow a manually-driven lead vehicle’s trajectory without cutting corners on turns. Our testing was done on MultiAgent Tactical Safety (MATS) vehicles that were provided by DRDC. Since there are no inter-vehicle communication links, the lead vehicle’s position, the goal of an autonomous follower is to track the trajectory of its immediate leader (with Professor Tim Barfoot)  
3. Infinite lattices of dynamical systems: In studying the formation of a very large number of vehicles, one approach is to model an infinite number of vehicles. The question then arises as to what mathematical framework to take so that the latter model correctly describes the behaviour of the former. This leads to the subject of infinite chains or lattices of dynamical systems. (with Professor Avraham Finkman)  

Frey, Brendan  
Algorithms for Inference and Machine Learning  

www.gene.utoronto.ca  

Dr Frey’s group develops new inference theories that can be used for probabilistic and statistical inference in large-scale systems, such as those that arise in large-scale simulations, robotics, genetics, genomics, vision and signal processing. Dr Frey is co-author of an article that introduced the factor graph and associated sum-product and max-product algorithms (IEEE Trans Info Theory 2003). A factor graph is a method for decomposing high-order probability models into simpler terms, so that the sum-product or max-product algorithm can be used to efficiently perform inference. A search for “factor graph” on Google returns over 40,000 hits. Other methods developed by Dr. Frey and his colleagues include variational methods for inference in large-scale non-linear Gaussian models (NeurComp 1999), a technique for learning in take-samples of large data sets (Science 1995), cumulative distribution networks (NIPS, UAI 2008) and loopy belief propagation algorithms for low-variance convex optimization (CVPR 2009), phase-unwrapping of medical and satellite images (NIPS 2001), exemplar-based clustering (Science 2007) and facility location (AISTATS 2010).
**Data Analysis and the Affinity Propagation Algorithm**

Because of its simplicity, general applicability and performance, the affinity propagation algorithm is widely used in science and engineering. In the past year, an on-line web tool developed by Dr. Frey’s group was accessed over 100,000 times by over 3000 users (unique IP addresses). 600 of which were from Canada. Google returns over 10,000 hits for the search term affinity propagation. Dr. Frey’s method has been applied to solve problems in biology, genomics, medicine, physics, chemistry, telecommunications, electronics, archeology, economics and social networks.

**Deciphering the Human Genetic Code**

The second level of information hidden in the genome that can account for the exponentially greater complexity required to create a human being. The work of Dr. Frey’s team was reported in the Globe and Mail, the Toronto Star, on CBC Radio, BIBC Radio and in a variety of other national and international news.

Dr. Frey leads an ongoing, multi-year project whose goal is to infer the coding mechanisms underlying the regulation of genes. The project involves experimental collaborators from the Centre for Cellular and Biomolecular Research at the University of Toronto, along with international collaborators. Several of the students and postdoctoral fellows who have graduated from Dr. Frey’s lab have subsequently taken faculty positions at leading universities, including UPMC, UNC and Harvard.

**Gulak, Glenn**

In the area of digital communications, we have continued to develop several practical ways to improve the performance and implementation of wireless systems that use multiple antennas (MIMO) for improved diversity and capacity. One of the key elements that we have investigated is the subsystem in the baseband known as the detector, which is responsible for data detection. A key contribution is the creation of an innovation that we call an on-demand K-best algorithm (a breadth-first search technique) whose complexity scales linearly with constellation size. This innovation is key to supporting higher order modulation schemes such as 64-QAM and 256-QAM systems that will appear in next-generation communication standards, necessary for Gigas performance. We have implemented and tested our algorithm in 0.15um CMOS and have generated the best-known results published in the literature to date, with respect to data rate, power efficiency and area. Our results have been extended to soft detection and tested with CMOS prototypes for use with iterative REC decoding schemes. We have also made recent contributions to an important channel pre-processing block found in all MIMO systems, namely that of QR decomposition, a function needed for decoupling the channel matrix. Our key contribution in this area is the development of both algorithms and a 0.1um CMOS implementation that demonstrates the world’s lowest (best) processing latency. Another area of recent accomplishment is in a channel pre-processing element known as Lattice Reduction. The key innovation is to reorthogonalize the signal space with the objective of improving BER performance. We have developed several algorithmic innovations and the world’s first CMOS prototypes for Lattice Reduction; the concepts developed will be particularly attractive for low-power implementations. The future work focuses on next-generation OFDM basis signal processing algorithms and their high-performance, low-power CMOS realization.

**Hatiznakos, Dimitrios**

**Biometrics User-Centric Sensor Networks (BUSNET)**

We propose to develop an integrated security architecture to effectively and efficiently secure and protect sensitive information and data within the domain of a care enterprise, such as wireless health care and home care applications and services. Our proposal addresses the need for secure communication and authentication of personal information, which also requires enhanced privacy and confidentiality. The proposed security architecture, "Biometrics User-Centric Secure Networks (BUSNET)" will implement novel biometrics-based security solutions and technologies that can be effectively integrated into a platform of wireless health care infrastructures. Specifically, this research initiative will be examining issues and developing solutions for processing of biometrics data, biometrics registration and authentication and biometrics key generation and management, as well as biometrics-based data authentication. Implementations of the proposed architecture using specific realizations of available wireless Body Area Network (BAN) configurations will be also developed, examined and analyzed in collaboration with our industrial partners. The proposed security framework constitutes an effective mechanism that integrates a novel security architecture and a cost-effective networking configuration to develop a realistic, feasible and cost-effective solution for secure transmission of sensitive health care information. Specifically, this research initiative will be examining issues and developing solutions for processing of biometrics data, biometrics registration and authentication and biometrics key generation and management, as well as biometrics-based data authentication. Implementations of the proposed architecture using specific realizations of available wireless Body Area Network (BAN) configurations will be also developed, examined and analyzed in collaboration with our industrial partners.

**Efficient Resource Allocation Strategies for Wireless Multimedia Communications**

One of the major objectives of multi-generation communication networks is to provide high-quality multimedia content to users. This demand necessitates more efficient utilization of limited resources such as power and spectrum. While it is essential to minimize consumption of these resources, the conservation should not come at the cost of inferior quality of service (QoS). As a result, power- and spectrum-efficient strategies, that can also guarantee some level of QoS, are highly desirable. We propose a generalized framework of resource allocation, which enables efficient integration of various adaptation methods and strategies: efficient use of available bandwidth, adaptive modulation and coding, and highly varying wireless channel conditions, and an integrated and modular design for overall performance gain. With dynamic resource allocation, improved flexibility and robustness can be obtained in the hostile wireless channel environments. Various channel distortions can be mitigated efficiently, successfully accommodating various user needs in a wide range of scenarios. Depending on the application, a pre-selected level of QoS can be guaranteed while keeping resource consumption to a minimum. Together, these strategies offer an attractive communication framework of increased power and spectral efficiency, which will enable high-data-rate wireless multimedia communication to be an affordable and practical reality.

**Medical Biometrics**

The cardiovascular system offers a variety of physiological signals that can be used as biometrics. While modality such as the electrocardiogram (ECG) is still relatively novel, it is increasingly gaining acceptance as a useful biometric tool, because of some unique characteristics. Existing solutions for biometric recognition from electrocardiogram (ECG) signals use either template and similarity distances between detected fiducial points. Such methods rely heavily on the accuracy of fiducial detection, which is still an open problem.
due to the difficulty of exact localization of wave boundaries. To avoid fiducial points detection, the signal is processed holographically, using second order statistics. Our autocorrelation-based method is a very simple and effective approach that does not require any wave- form detection. It depends on estimating and classifying the significant coefficients of the Discrete Cosine Transform (DCT/CDCT) or the Linear Discriminant Analysis (LDA/CDA) of the autocorrelation of heartbeat signals. The LDA/CDA algorithm has been incorporated into a prototype system developed at the BioclicLab, HeartID. HeartID is a Matlab-based software with various functionalities, such as user enrolment, database handles, security level adjustment and identification/verification modes of operation.

Bragg reflection waveguide lasers have the potential to enable the creation of system software and middleware for the extraction, processing and characterization of real-time sensed data. One of the key contributions of this task involves the advancement of innovative mobile social networking technology, which has the secondary benefit of enhancing next-generation video, video and data transfer in addition to security/privacy mechanisms. The University of Toronto will leverage “Altelecom”s current status of the research, including research-focused infrastucture for collecting massive amounts of sensor data in order to provide critical functionality for (i) management of inconsistent and insufficient data; (ii) efficient remote monitoring and decision-making; and (iii) efficient social network analysis; and (iv) various enhanced security functions for device authentication and data protection under a wide range of attack scenarios. (2) Creation of innovative energy conserving, capture and storage technologies that use novel nanoscale materials, energy harvesting methods and renewable energy resources to supply consistent power to sustain autonomous sensor networks. The research on self-powered sensor energy systems will focus on five major areas: (i) power conditioning and conversion; (ii) electronic energy harvesting; (iii) solar energy harvesting; (iv) vibrational thermal energy harvesting; and (v) energy storage. The ultimate target is low cost, miniaturized, readily integrable, 24/7 energy generation systems that can sustain on the average a few hundred mW pulses, as well as support continuous current draw at mA scale. Several, if not all, of the energy generation techniques will undoubtedly be extended to this next-generation, large-scale wireless technologies to further reduce dependence on fossil fuels and other environment-affecting resources.

Photonics Integrated Circuits for Ultrafast All Optical Signal Processing

Parametric processes based on second-order optical nonlinearities in III-V semiconductors are an ideal platform for the development of novel parametric devices for all optical signal processing. The efficiency of parametric processes crucially relies on the phase-matching technique employed. Because of the lack of natural birefringence in compound semiconductors, phase-matching can be challenging in these materials. Our group has proposed and successfully demonstrated an exact phase-matching technique using Bragg reflection waveguides (BRWs) in the AlGaAs material system. Current research focuses on improving the conversion efficiency of the nonlinear processes by investigating advanced transverse waveguide geometries as well as extending the technique to second-order nonlinear processes.

Quantum Photonic Devices and Circuits

Photons, the particles of light, play a pivotal role in the emerging area of quantum information science, such as optical quantum computing and quantum cryptography. However these futuristic technologies only exist in specialized labs, practical commercial systems are not available to date. One of the reasons these technologies have not moved into practical settings is that they need to be implemented using bulky components that are not portable and are sensitive to vibrations. Current technologies required to produce the building blocks of quantum systems do not allow a high level of integration of these components. These include devices for the generation, manipulation and detection of paired photons that are entangled. These entangled photons are an essential building block for quantum systems as required by quantum mechanics. For example, the main stream technique to produce entangled photon pairs is to use a strong laser beam to hit a nonlinear crystal. With a probability of 10^-9, 1 photon in the laser can be converted into a pair of entangled photons. Such a system is extremely inefficient and very energy-consuming. Besides, interference within a network of PSW junctions can enable the design of multiport multi-output optical devices with diverse functionalities. In order to reduce the computational cost associated with designing PSW devices through numerical techniques, our research also involves creating analytical models for PSW mesh structures. By approximating PSWs as microwave transmission lines, a scartching matrix model based on characteristic-waveguide impedance has been formulated to model the dispersion of localized plasmonic waves within mesh structures. The transmission responses of the mesh are uncapsulated into generic closed-form expressions that can handle arbitrary combinations of junctions without requiring numerically-exact parameters. Thus, the model is a scalable, efficient, and flexible framework that can be adapted to model specific mesh configurations as well as perform device design, optimization and sensitivity analysis.

Helmy, Amr S.
Infrared and THz Semiconductor Laser Chips

Bragg reflection waveguide lasers are essentially one-dimensional photonic bandgap structures that are doped in a p-n profile, where light is guided by Bragg reflectors with light propagating parallel to the p-n layers. The core is a layer of low-refractive index material and the device operates in Bragg reflection waveguide (BRW) mode, not the conventional total internal reflection mode. Bragg reflection waveguide lasers have the potential to enable the realization of high-power single-mode lasers and amplifiers with large mode volumes, high gain coefficient and strong mode discrimination. Moreover, this class of novel lasers has also shown potential in applications related to nonlinear frequency conversion, monolithically integrated optoelectronic integrated circuits.

Alpha-listing by Lead Researcher

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The great potential of HCPCF for optical sensing originates from the increased light-matter interaction volume and efficient accumulation of the Raman scattering along the extended length of the HCPCF. The well-confined excitation interacts directly with the sample molecules while propagating along the length of the HCPCF and Raman scattering can be efficiently excited along the fiber's entire length. Recently a detailed, non-destructive characterization of CdTe nanorod structures was carried out using Raman spectroscopy for solutions with OD concentration of 2 mg/mL, which is similar to their concentration during the synthesis process. By employing the HCPCF platform not only for light-matter interaction, but also for the pump laser and the OD solution can be confined within the core of the HCPCF. Subsequently, the confined laser power within the core induces a strong interaction with the solution that is filled inside which allows an enormous amount of Raman signals to be induced and collected compared to the conventional Raman scheme. With this novel technique, Raman signals from aqueous or diluted solutions can be enhanced by two to three orders of magnitude without the use of additional metallic nanoparticles. This enhancement allows clear vibrational modes corresponding to the structure and interactions of the CdTe to be observed. These vibrational modes include those of the CdTe core, defect and CdTe:ZnO:3 interfaces. Thiol agent and carboxylate-metal complexes. These modes are correlated with the crystallinity of the CdTe core, interfacial structure formation upon stabilization, CdTe:ZnO:3 interference mechanisms, water solubility of the CdTe and their potential bio-conjugation abilities.

Herman, Peter

**3D Laser Fabrication: Enabling Nano-optics for the Nanosciences**

Nanoscience and nanotechnology define significant trends today that seek to exploit the new physical laws that govern the structures and devices we make: these changes are without a doubt well under way, and we are beginning to realize that new devices and technologies will arise from the study of these fundamental changes. The ultimate effect of this research will be to form the framework for a new generation of materials. The new devices will be used to exploit the quantum effects that dramatically alter the electrical, magnetic, and optical properties of materials at the nanoscale. The field of nanophotonics, which combines nanotechnology and photonics, has emerged as the new discipline. A key research area in this field is the development of nano-optics that promise to enable new optical materials, such as photonic bandgap crystals, nanofibers, and nanomaterials, to guide light at dimensions below the wavelength of light. Nano-optics has emerged as a new discipline that promises new optical materials (photonic bandgap crystals, metamaterials, plasmonics) to guide light at dimensions below the wavelength of light. Nano-optics is based on the same principles as quantum mechanics, but its applications are limited to dimensions much smaller than the wavelength of light. Nano-optics has emerged as the new discipline that promises new optical materials (photonic bandgap crystals, metamaterials, plasmonics) to guide light at dimensions below the wavelength of light. Nano-optics is based on the same principles as quantum mechanics, but its applications are limited to dimensions much smaller than the wavelength of light.

**Intelligent Beam Control for Ultraslim Laser Fabrication of Photonic and Biomedical Microsystems**

The synergy of colours and lights flashes generated during laser machining attest to the dramatic evolution of physics as a result of theoretical work and experimental research. As a result of the development of new techniques to fabricate miniature medical devices, bio-sensors and Telecommunication products, and as a result of the development of new techniques to fabricate miniature medical devices, bio-sensors and Telecommunication products, the proposed program aims to improve the fundamental understanding of laser interactions at the forefront of "burst" ultrashort laser processing and self-focusing "flattening" machining — effects first discovered by our group. Our aim is to turn this understanding into "intelligent" laser control methods that can manage the highly nonlinear light interactions in transparent materials and possibly open a new direction for three-dimensional manufacturing. A novel burst conventional diffraction limits or probe the electron wavefunction of protein molecules with a powerful enhanced optical resolution.

To this end, the proposed NSERC program seeks to invent a new means of laser optical beam delivery that will facilitate the fabrication of 3D nano-optical systems. Near-field and phase-shifting techniques will be exploited in multi-mode diffraction optical elements to design "intensity defects" within 3D periodic interfering laser patterns. Photoluminescence optical elements exposed to these modified laser patterns will see nano-optical devices precisely assembled at the critical points of a 3D periodic lattice to enable the nanofabrication of compact 3D nanophotonic circuits, 3D optical-domain metamaterials and nanofluidic chromophotography sensors for cell proteomics. This significant extension of laser holography promises a powerful advance in nanophotonics and defines a new paradigm for high-volume manufacturing — contactless 3D nanomanufacturing — significance to Canada's optics, biophotonics and nanotechnology industry.

Itravani, Reza

**Real-Time Simulation, Control and Protection of Distributed AG Power Systems**

This work includes research and development of analytical and time-domain-simulation tools and control and protection software algorithms for: (i) interconnected AG power systems that interact over High-Voltage Direct Current (HVDC) grids, mainly for large-scale inte-

lization of wind and solar power, and (ii) microgrids with high-depth of penetration of distributed generation and storage units.

Iizuka, Keigo

**Omni Focus Video Camera**

Our main challenge during the past recent was the invention of two novel types of mapping video cameras. The first invention, called the Divcam, is a distance mapping camera that operates on the combined principles of time of flight and modulated illumination. Television programs produced by using the Axi-Vision Camera have been broadcast from NHK, Japan.

In a contest sponsored annually by Optical and Photonics News of the Optical Society of America, the paper on the Axi-Vision Camera was selected as one of the most significant scientific accomplishments described in a refereed journal in 2002. The Axi-Vision Camera lab was commercialized by NHK Enterprises, Japan and the first unit was sold for $400,000. We received the 2003 Fuji Pioneer Award in recognition of our loading-edge research and development of the Axi-Vision Camera.

The second invention, called the Divcam (short for Divergence Ratio Camera), is a distance mapping camera that utilizes the universal decay rule of the illuminating light with distance. The Divcam is light weight, compact, portable and reliable, has a fast response and is low cost. A U.S. Patent was filed on the Divcam and later extended to an international patent through the Patent Cooperation Treaty. The omni-focus video camera, which needs the information of distance, was invented as a natural extension of the Divcam. Its invention was reported by various news organizations and magazines, including
Joy, Mike  
www.currentdensityimaging.org/  
Current Density and Conductivity Imaging with MRI  
This is a very active research area. Every decade a new medical imaging technology appears or matures. The most recent of these is magnetic resonance imaging (MRI). We are investigating the use of magnetic-resonance imaging for tissue characterization. The goal here is to physically characterize not just the shape of an organ or nonplanar but also the tissues within it. We are also studying electric current density imaging with potential application in electrical safety, therapeutic electrical stimulation, management of electrical burns, impedance tomography and solution of the inverse problem of the measurement of bioelectric sources.

Kherani, Nazir  
Kherani, Nazir  
High-Efficiency Silicon Photovoltaics  
The objective of this project is to research, develop and integrate a set of thin-film technologies that will lead to prototype demonstration of high-efficiency silicon photovoltaic solar cells. The novelty of the research lies in the development and integration of unique, production-worthy technology elements which will ultimately make it possible to attain the lowest cost per watt peak (Wp) of silicon-based photovoltaic solar cells. Silicon is one of the highest potential energy conversion efficiencies. This property, along with its stability, abundance, environmental compatibility and technological maturity, make silicon a prime material for photovoltaics. However, the challenge today is cost. Cost reduction can be achieved by decreasing production and material costs and by increasing energy conversion efficiency. The unique technology elements comprising this project are (1) development of high-efficiency solar cell concepts with the objective of producing the greatest quantity of solar electricity per gram of silicon (i.e., thin silicon), (2) use of low-temperature, high-quality thin-film synthesis techniques with the objective of implementing low-temperature-high production-rate processing, and (3) integrated development of photonic concepts, photon harvesting techniques and production processes compatible with the drive to continually reduce the silicon absorber thickness.

Johns, David  
www.ece.utoronto.ca/~johns  
Advanced Interface Circuits for MEMS Technology  
The aim of this project is to investigate photonic crystal-photovoltaic integrations with the aim of creating high-efficiency, economic, third-generation solar cells. The novelty of the research lies in innovative integrations of nanomaterials and thin-film semiconductors. As thin-film crystals or nanocrystalline silicon solar cells are made thinner, light sampling at wavelengths near the absorption edge becomes increasingly important (e.g., absorption lengths are 10 mm and ~1 mm for wavelengths of 800 nm and 1100 nm, respectively). Upon applying perfect random scattering on an incident silicon surface with a lossless back reflector, a maximum path length enhancement of ~50% is expected, though in reality the actual value is closer to 10%. However, much larger path-length enhancement factors, on the order of 103 to 104, are required to effectively absorb the longer wavelengths. An alternative approach is to focus light through the application of photonic crystals. Photonic (PC) are periodic dielectric structures that affect the behaviour of electromagnetic waves similar to periodic potentials in semiconductor lattices that affect the behaviour of electron waves.
codes, so-called spatially-coupled algebraically-decodable codes, (hundreds of Gbits/s per wavelength) and designing error-control
Optical fibres support very high-speed communication channels
Spatially-Coupled Algebraically-Decodable Codes for High-Speed Data Transmission
allows two (or more) users to transmit simultaneously. In this case, a compute-and-forward (C&F) relaying strategy that is emerging as
Energy of Decoding
The capacity of an additive white Gaussian noise channel depends
Kochschang, Frank
Energy of Decoding
This work studies information transmission techniques based on
Fibre-Optic Communication Using the Nonlinear Fourier Transform
Fibre-optic transmission systems are evolving at a rapid pace towards
achieving greater spectral efficiencies. Coherent detection is a precluding
noncoherent detection and polarization multiplexing and advanced
modulation schemes are being implemented. Today’s high-speed electronics enables very sophisticated signal processing and coding to
be applied, even at extremely high data rates, there is a significant gap between what has so far been practically achieved and what
is known to be achievable in theory.
In this work, we study information transmission techniques based on
the nonlinear Fourier transform. The nonlinear Fourier transform (NFT), in a powerful tool in signal theory and exactly solvable models, is a
method for solving integrable partial differential equations governing wave propagation in certain nonlinear media. The NFT decomposes
signal degrees-of-freedom in such models, in much the same way that the Fourier transform does for linear time-invariant systems. In the
proposed communication scheme, which can be viewed as a nonlinear analogue of orthogonal frequency-division multiplexing commonly
used in linear channels, information is encoded in the nonlinear frequencies and their spectral amplitudes. Unlike most fiber-optic transmission
schemes, the techniques dealt with both dispersion and nonlinearly directly and unconditionally without the need for dispersion
or nonlinear compensation methods. Much work remains to be done, however, in translating this theoretical idea into practice.
Physical-Layer Network Coding
Nested-lattice-based physical-layer network coding is a type of compute-and-forward (C&F) relaying strategy that is emerging as
being a compelling information transmission scheme in Gaussian relay networks. While most wireless protocols try to avoid interference, C&F
allows two (or more) users to transmit simultaneously. In this case, a (random) linear superposition of the signals is observed by the relay. Rather
than discarding this information, or attempting to separate the messages, the new idea of C&F is that the relay can attempt to decode a linear combination of the messages being transmitted, i.e., a “linear equation.” Such linear equations can be forwarded to the next relay and so on. Exploiting the property that a linear combination of linear equations is again a linear equation, the eventual destination is presented with a linear system to solve to recover the original messages. There are many potential practical applications of this idea, in particular, it may be possible to design new MIMO relays that can toler-
ate much more interference (many more active users) than existing ones while still providing high-quality network access.
Spatially-Coupled Algebraically-Decodable Codes for High-Speed Data Transmission
for such applications. This family includes “staircase codes,” a hardware-friendly class of codes with excellent code performance.
Our ongoing research is investigating methods to incorporate soft-decision information and to combine coding with higher-order modulation.
Khisti, Ashish
Low Delay Communication Systems for Streaming Media
Through the exploration of a range of nano-integrations, we have recently proposed a novel class of transparent conducting porous nanocomposite films amenable to a variety of device applications. One application involves the use of a selectively transparent and
conducting photonic crystal as an intermediate reflector for efficiency enhancement of tandem thin-film silicon microchip solar cells. Other application areas include biocatalysis, PLEDs and catalytic process applications.
Kundur, Deepa
Cyber-Physical Protection of the Smart Grid
The emerging smart grid represents an engineering system with tightly
coordinated and connected physical and cyber components. The close
interdependence of such diverse components may lead to emergent system behaviors and new forms of vulnerabilities. However, opportunities
can also exist through the coupling to improve system survivability to faults and attack.
This research project pioneers the development of a modelling and
analysis methodology for cyber-physical smart grid systems by harnessing the power of dynamical systems frameworks. Through
integration of mathematical tools from the fields of nonlinear dynamical systems, graph theory and game theory, we aim to address timely and
important system operation, control and security problems influenced by the needs of electric power utilities.
A Cyber Security Impact Analysis Framework for the Electric Smart Grid
The scale and complexity of the smart grid, along with its increased connectivity and automation, makes the task of cyber protection par-
ticularly challenging. Recently, smart grid researchers and standards bodies have developed technological requirements and potential
solutions for protecting cyber infrastructure. However, grid protection remains daunting to asset owners because of resources limitations.
Important questions arise when identifying priorities for design and protection. Which cyber components, if compromised, can lead to significant power delivery disruption? What grid topologies are inherently robust to classes of cyber attack? Is the additional
energy available through advanced cyber infrastructure worth the increased security risk?
The goal of this project is to develop a framework to assess the impact of cyber attacks on the electric smart grid. Our approaches
borrow from mathematical principles from control and communication theory to identify new vulnerabilities stemming from the use of cyber infrastructure and the relative physical impact of cyber attacks. One outcome is a vulnerability analysis tool that can be employed by smart grid stakeholders to identify critical cyber infrastructure that must be prioritized for system hardening.
Kwong, Raymond
3D Conformal Thermal Therapy of Soft Tissues for the Treatment of Localized Cancer using MRI-Controlled Ultrasound Therapy
MRI-guided ultrasound therapy is a powerful method of cancer treat-
ment in which ultrasound energy, guided by magnetic resonance imaging, is used to coagulate a target region of tumour. This kind of
therapy has been developed as a non-invasive alternative to conven-
tional therapies such as surgery and radiation, which often lead to long recovery times with high complication rates. Successful
application of this technology for treatment of localized cancer
Dependability and Security in Control and Multimedia Systems
Control and multimedia systems have become increasingly
sophisticated and complex. Failures in these systems can lead to large financial losses or even catastrophes. For control systems, our
research combines advanced tools from control and artificial inter-
ligence to detect failures or discover previously unknown faults. We
integrate diagnostic information to reconfigure control systems so that they are dependable even when failures occur. We seek to make mul-
timedia systems more secure by designing new strategies to embed forensic information that protects copyrights, is resilient under content manipulation attacks and detels piracy.
Lehn, Peter
Power Electronics to Enable More Sustainable Electrical Energy Networks
Professor Lehn’s research lies in the area of medium- and high
power applications of power electronics to form more reliable, cost-effective and sustainable electrical energy systems. Of specific interest is the
development of converter systems and network architectures for low
power, low-cost integration of wind, solar and energy storage resources, including plug in hybrid-electric vehicles. Improving robustness and
Alpha-listing by Lead Researcher

**Lead RESEARCHER**

**Research Title**

**Colour Key**

**Leon-Garcia, Alberto**

Application Platforms and Smart Infrastructure

We are developing systems for the control and management of resources in power utility grids, transportation systems and cities. These systems leverage the collection of state information using a vast array of sensors. We use a service-oriented approach to resource management that extends methodologies from cloud computing and high-power applications revolves around exploitation of established computing and communications infrastructure that can support the rapid deployment of large-scale distributed applications. A key innovation in SAVI is the notion of a smart edge that complements remote datacenters to build an extended cloud. A major goal of SAVI is to develop a national testbed to support experimentation in future internet protocols and architectures as well as future large-scale applications.

**Optical Biosensors and Biomedical Imaging Systems**

Our research interests include developing biomedical imaging systems and optical biosensors based on semiconductor devices and nanotechnology and their application to biomedical diagnostics. Our goal is to develop an integrated virtualized converged computing and networking platform to enable smart applications for transportation and government. It is typical for enterprises to rely on services from cloud providers in order to build a scalable platform with abundant available resources to satisfy user demand and for cloud providers to deploy a number of datacenters interconnected with high-capacity links across different geographical regions. We argue that multi-party video conferencing even with its stringent delay constraints, should also be provided as a cloud service, taking full advantage of the inter-datacenter network in the cloud. We present AirH, a new protocol designed for the inter-datacenter network, tailored to the needs of a cloud-based video conferencing service. AirH delivers packets in live video conferences to their respective destination datacenters with the objective of maximizing the total throughput across all conferences, yet without violating end-to-end delay constraints. To make this optimization problem easier to solve, AirH uses intra-session network coding and the notion of conceptual flows. A real-world implementation of the AirH protocol has been developed, which shows that our new protocol design performs substantially better than state-of-the-art peer-to-peer solutions.

**Liang, Ben**

Broadband Multimedia Communication in the Mobile Environment

Multimedia content is the single most influential factor driving the need for increased mobile network capacity and device capability. The proliferation of cloud-based content distribution services and video social networking applications will severely stress the existing mobile systems and optical biosensors and apply them to novel biology and biomedical applications. As such, our research is interdisciplinary and includes semiconductor device physics, optics, micro- and nanofabrication, chemistry and applications in biomedical diagnostics, cancer studies and neurobiology.

**Li, Baochun**

Airlift: Video Conferencing as a Cloud Service

Using Inter-Datacenter Networks

We are developing an architecture for new network and service management and control systems that can support the rapid deployment of large-scale distributed applications. A key innovation in SAVI is the notion of a smart edge that complements remote datacenters to build an extended cloud. A major goal of SAVI is to develop a national testbed to support experimentation in future internet protocols and architectures as well as future large-scale applications.

**Optical Platforms for Ultra-scale Datacentres**

We are designing optical networks that can provide connectivity for future datacentres that can interconnect several million servers. At this scale, power consumption, footprint and space for Ethernet cabling become severe challenges that can be addressed through the deployment of optical multilayer transmission and switching technologies.

**Design of Converged Communications and Computing Infrastructure**

In this project we are investigating the migration of the telecom service delivery platform to enable smart applications for transportation and government. It is typical for enterprises to rely on services from cloud providers in order to build a scalable platform with abundant available resources to satisfy user demand and for cloud providers to deploy a number of datacenters interconnected with high-capacity links across different geographical regions. We argue that multi-party video conferencing even with its stringent delay constraints, should also be provided as a cloud service, taking full advantage of the inter-datacenter network in the cloud. We present AirH, a new protocol designed for the inter-datacenter network, tailored to the needs of a cloud-based video conferencing service. AirH delivers packets in live video conferences to their respective destination datacenters with the objective of maximizing the total throughput across all conferences, yet without violating end-to-end delay constraints. To make this optimization problem easier to solve, AirH uses intra-session network coding and the notion of conceptual flows. A real-world implementation of the AirH protocol has been developed, which shows that our new protocol design performs substantially better than state-of-the-art peer-to-peer solutions.

**Optimizing Datacentre Operations with Practical Complexity**

The unprecedented growth of mega-datacentres, in which hundreds of thousands of machines are assembled to process a massive amount of data for Internet-scale services, has been driving the evolution of computing. Designing algorithms to optimize datacentre operations is thus imperative. At the same time, the scale of the infrastructure calls for novel approaches to reduce the complexity of the solutions in order to make them practical. In this project, our research objective is to resolve the tussle between optimality and practicality in designing algorithms for datacentres. First, for a single datacentre we have designed Anchor, a resource management system that effectively allocates server resources to virtual machines. Instead of being optimal, Anchor is designed to be feasible and practical and uses a unified mechanism to support diverse allocation policies expressed by operators and tenants. It abstracts performance goals as preferences and uses a novel stable matching algorithm to solve the matching problem efficiently. We have also studied the problem of workload management for multiple centres distributed over a wide geographical area, where it is possible to go for both optimality and practicality. I propose to exploit the geographi- cal diversity to reflect the electricity and bandwidth price difference at different locations and ISPs and develop a novel distributed algorithm to solve the large-scale optimization problem with faster convergence than that of traditional methods.

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algorithm design to create innovative technologies for multimedia communication in the mobile environment. Promoting a synergistic

Fair Resource Scheduling in Large-Scale Networked Systems

The principles of network science permeate wide-ranging applications such as communications, cloud computing, power grid management, transportation, and biology. A central issue is how to effectively share network resources among competing agents. We are interested in developing new theories and practices for fair resource scheduling in largescale networked systems. Examples of our investigation include cloud computing economics, distributed smart grid regulation service and multi-resource fair scheduling.

Resource Management and Optimization in Wireless Networks

In next-generation heterogeneous wireless networks, the increased number of networked devices and the broadband nature of application demands will increase the need for efficient resource sharing. The goal of this research is to develop fundamental theories, networking algorithms and communication protocols for efficient allocation of spectrum, hardware and power in high-throughput wireless networking environments. Our investigations include stochastic optimization, distributed computing and co-operative communication.

Lo, Hoi-Kwong

Quantum Key Distribution

Quantum cryptographic systems are, in principle, unconditionally secure. In practice, quantum hacking has emerged as a key challenge to their security. To foil quantum hacking, we have recently proposed an entirely new approach — measurement-device-independent quantum key distribution (MDI-QKD) — that can “short-circuit” all detector security loopholes. In other words, the system will be automatically immune to all detector side channel attacks. This is remarkable because it means that commercial QKD detection systems would no longer require any special security certifications and, in fact, they can even be manufactured by a malicious eavesdropper.

We will build a prototype MDI-QKD system and demonstrate its robustness against detector side channel attacks. We will also develop the theory of MDI-QKD and take into full account various implementations in real-life devices. Our work will allow us to use our enemy in quantum cryptography.

Quantum Cryptography: From Theory to Practice

In contrast, quantum code-making offers perfect security in communication, based on the laws of physics. Our goals are to dramatically improve both the performance and the security of practical quantum key distribution systems. We do so through system building and studying hacking strategies and countermeasures.
AugmentedReality will Never Work and That’s Why We Need MediatedReality

Augmented reality, whether by handheldiPhone applicationsdevelopedin our lab and elsewhere, or by eyePhone (electric eyeglasses) and antenna arrays, has been shown to be problematic because it causes informationoverload. What we’ve learned is that an older concept called “mediated reality”overcomes these problems. We’ve developed

Virtual Constraints: A New Paradigm for the Control of Motion

This traditional approach to making robots perform complex motions relies on a hierarchical decomposition of the control task: motion planning at the high level and feedback control at the low level. This approach has proven to be inadequate in complex motion control problems such as locomotion in multi-legged robots or flight in bird-like robots. This research aims at developing a new paradigm for motion control. This paradigm is based on the concept of virtual constraint—a

FormationControl of Nanosatellites

The electric actuators used to propel nanosatellites (electric thrusters) produce very low thrust with low resolution. Those two factors, combined with tight specifications on the accuracy of the control task, make formation control particularly difficult. This research, in collaboration with Professor Chris Damaren at UTIAS, aims at developing a formation control methodology that takes into account the characteristics of electric thrusters and solves the formation control problem with the required accuracy.

Wearcam.org/ece516/

Since early childhood I’ve been wearing a computer system that captures my life. In the 1990s I miniaturized this into a necklace with fish-eye lens and various sensors (wearcam.org/neckcam.htm) and presented this work to Microsoft as the Keywords Address of CARPE in 2004. Microsoft has subsequently manufactured a similar product called SenseCam. Other companies such as DARPA, HP Labs and www.wearcam.org/furutan.htm

Combination of Torque and Thrust

Each vehicle can only sense its relative displacement, orientation and acceleration. Absement, absity and abseleration arise in fluid flows. Absity is the time-integral of displacement. Integrating once more gives absement. Integrating again gives absity. Integrating once more gives acceleration. But what happens when you take

Brain-Computer-Interaction (BCI)

products around the world. BCI based on the ChipIt Transform (http://wearcam.org/ChipIt.htm) has been the subject of several PhD theses and a number of research papers. See www.eyeTap.org/publications.

Comparative Equations and

High Dynamic Range (HDR) Imaging

High Dynamic Range Imaging has many applications, such as in electric eyeglasses. On the plus-math side, there is the theory ofcomparative equations. On the practical side, there are applications in extending the dynamic range of imaging devices such as electric eyeglasses, portable cameras and cellphones.
solution. Plasmonic waveguides, like optical interconnects, have small latency and large bandwidth but, unlike the optical interconnects, they can be easily miniaturized. However, plasmonic waveguides have their own challenges. Chief among these are (1) large propagation losses, and (2) lack of various efficient and integrated plasmonic devices such as polarizers, directional couplers and bends, to name a few. In order to overcome the losses associated with SPP while maintaining a small device size, our group was among the first to propose a hybrid plasmonic waveguide (HPWG). The HPWG can be viewed as an optimized structure exhibiting a compromise between loss and mode size. Moreover, fabrication of our HPWG is compatible with the existing silicon technology. Our HPWG can be used as a building block for the next generation of plasmonic devices such as TM- and TE-pass polarizers, polarization independent couplers and other novel components.

Moshovos, Andreas

www.ee.ualberta.ca/~moshovos

Embedded and mobile handheld devices have been miniaturizing, enabling applications that were not possible or cumbersome with the big iron machines of the past. Each new generation of these devices offers more capabilities than the previous generation of handheld devices. While early mobile devices were capable of simple tasks and low bandwidth communication, today’s devices offer many more capabilities such as multimedia, navigation, digital photography, etc. As their capabilities are increasing, novel applications such as health monitoring will become feasible. For these possibilities to materialize, mobile and embedded systems need to become more powerful while maintaining reasonable power consumption.

Exploiting Multi-Megabyte OnChip Memory Hierarchies

Several technology and application trends favour chip multiprocessor (CMP) architectures, which integrate multiple processor cores, a memory hierarchy and interconnect onto the same chip. CMPs could be used for commercial servers and for end-user systems, as they can support both multiprogram and parallel/multithreaded workloads. They can also be used as the building blocks for shared multiprocessor (SPMPs). Designing high-performance and power-aware memory hierarchies and interconnects is imperative for CMPs in order to meet the memory demands of many processors and applications while not exceeding power constraints. Continuing application trends towards larger memory footprints, multiprocessor workloads and the ever increasing speed gap between off-chip and on-chip memory components put further pressure on the on-chip memory hierarchy and interconnect. Furthermore, off-chip interconnect poses us with new trade-offs and opportunities for optimizations that need to be exploited to deliver the expected performance. Additional opportunities are provided by stack-die and on-die DRAM technology that may be used to incorporate multigigabyte caches. The key questions addressed by this research are: (1) how do we manage these multigigabyte caches, as the techniques currently used still adequate, or is there room or need to rethink these decisions? and (2) Can we exploit this tremendous wealth of off-chip storage to further optimize performance by what is possible by simple caching additions to existing memory controllers? Accordingly, the proposed research comprises two thrusts. The first concerns the use of coarse-grain tracking to achieve performance that is otherwise not possible with conventional cache management techniques. The second exploits the on-chip caches to store program metadata in addition to instructions and data. Program metadata is information collected at runtime about program behavior that can be used to anticipate and optimize for future program demands.

FPGA-Friendly Processor Architectures for Irregular Applications

Our assertion is that, as embedded applications evolve, some of them will exhibit irregular behavior. We have demonstrated that conventional soft processors are inefficient for this purpose and have proposed FPGA-friendly designs for various processor structures.

Power-Aware Cache-Based Structure Design

Computing devices comprise processing elements that process digital information and memory elements for storing digital information. Because of technological constraints, memory tends to be significantly slower than the processing elements it supports. Accordingly, virtually all modern multiprocessor systems employ caches, which are additional small and fast temporary memories that serve to accelerate most references to the otherwise slow memory elements in recent years.
Privacy and Smart Data Management

Privacy and smart data management principles. It creates a radically new digital asset distribution paradigm where privacy-enhancing technology plays an important role. This approach enables the interaction to be more intuitive, flexible and efficient. We seek to support for development in the areas of (1) signal-image processing for 3D imaging applications, (2) image and data fusion for these multisensor systems; (3) Implementing of the signal-image processing developments for biometrics sensors (e.g. face recognition, iris recognition, fingerprint and voice recognition), (4) Privacy-Protected Video Surveillance

Privacy-Protected Video Surveillance

The proposed development is a privacy protection system for video surveillance. It protects the personally identifiable visual information of subjects appearing in video surveillance footage by performing reversible encryption on the corresponding pixel regions (e.g., the face). This is a unique and effective privacy-enhancing solution that can be applied immediately after video capture, but is reversible using a secret key, thus negating the need to store the unprotected original video footage in case an incident investigation occurs.

Signal and Image Processing for Stereoscopic Cameras, Biometric Sensors and Laser Radar Applications

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Nonlinear optical devices are also used for frequency conversion, optical nonlinearity and use the model for the design of compact, low-cost optical interconnects. They may become a complete flow from the Verilog Hardware Description Language through placement and routing, and timing analysis. It is called the “Verilog to Routing” (VTR) project. The new CAD software has the ability to describe far more complex FPGA architectures, including FPGA logic blocks with arbitrary hierarchy, modes of operation and interconnection structures.

Sarris, Costas
Advanced Radio Propagation Modelling for Next Generation Rail Signalling Systems
www.ece.utoronto.ca/pref/sarris
The public need for rail transportation safety can be effectively served by precise train control systems, which employ devices that are increasingly subject to fabrication process variability. Moreover, while electromagnetic simulators are now able to model large-scale wireless propagation problems, they are still limited by the inherent statistical variability of indoor and urban environments. In general, the development of powerful electromagnetic simulation tools that effectively incorporate statistical uncertainty is bound to have a far-reaching impact on the pace of technological advancement with respect to grand research challenges such as the design of low-cost yet efficient solar cells, the installation of CBTC systems. Conducting a radio survey requires significant resources (time, money and personnel) and it is often performed in the off-peak times of the day and week. However, several cutting-edge research areas, notably plasmonics and nanotechnology, employ devices that are increasingly subject to fabrication process variability. Moreover, while electromagnetic simulators are now able to model large-scale wireless propagation problems, they are still limited by the inherent statistical variability of indoor and urban environments. In general, the development of powerful electromagnetic simulation tools that effectively incorporate statistical uncertainty is bound to have a far-reaching impact on the pace of technological advancement with respect to grand research challenges such as the design of low-cost yet efficient solar cells, the installation of CBTC systems. Conducting a radio survey requires significant resources (time, money and personnel) and it is often performed in the off-peak times of the day and week. However, several cutting-edge research areas, notably plasmonics and nanotechnology, employ devices that are increasingly subject to fabrication process variability. Moreover, while electromagnetic simulators are now able to model large-scale wireless propagation problems, they are still limited by the inherent statistical variability of indoor and urban environments. In general, the development of powerful electromagnetic simulation tools that effectively incorporate statistical uncertainty is bound to have a far-reaching impact on the pace of technological advancement with respect to grand research challenges such as the design of low-cost yet efficient solar cells, the installation of CBTC systems. Conducting a radio survey requires significant resources (time, money and personnel) and it is often performed in the off-peak times of the day and week. However, several cutting-edge research areas, notably plasmonics and nanotechnology, employ devices that are increasingly subject to fabrication process variability. Moreover, while electromagnetic simulators are now able to model large-scale wireless propagation problems, they are still limited by the inherent statistical variability of indoor and urban environments. In general, the development of powerful electromagnetic simulation tools that effectively incorporate statistical uncertainty is bound to have a far-reaching impact on the pace of technological advancement with respect to grand research challenges such as the design of low-cost yet efficient solar cells, the installation of CBTC systems. Conducting a radio survey requires significant resources (time, money and personnel) and it is often performed in the off-peak times of the day and week.
Scardovi, Luca  
[www.ece.utoronto.ca/~scardovi/]

It is well recognized that control has proven to be an essential ingredient in almost every engineering system, ranging from power and automotive systems to space missions, and that feedback is a key element in many natural phenomena, ranging from molecular pathways to living organisms to ecological systems. Recent years have witnessed an increasing interest in systems that are comprised of (possibly many) interconnected units. As a whole, these systems often exhibit one or more features that cannot be predicted from the properties of the individual parts. These properties (called emergent behaviour) are not an attribute of any single entity; they are irreducible and are generated by their interconnection. Emergent behaviour can lead to surprising and useful phenomena such as memory, intelligence and self-organization in cells, but can also have disastrous consequences. Examples include the spread of infectious diseases, neuronal synchronization disorders in the brain, collective motion in bacteria and locust swarms. It is therefore of great interest to understand the principles behind the emergence of such properties and investigate solutions to control them. The control and systems-theory paradigm is natural in this context, but unfortunately all-the-sleave techniques are not always appropriate for such complex systems. In the present research effort, we propose to overcome these limitations by developing new principles and methodologies that go beyond classical stability and regulation theory. Future applications range from the domain of biological networks to that of the complex man-made systems, and include closed-loop control of neuronal synchronization, analysis and control of synthetic biological circuits, and coordination in autonomous sensing networks, amongst others.

Sheikholeslami, Ali  
[www.ece.utoronto.ca/~ali]

Spin Electronics (or spintronics) is a new and emerging field of science and engineering that exploits the spin of electrons, in addition to their charge, for the purpose of information storage, transport and computation. Prototypical examples include magnetic sensors, transport phenomena in magnetic superlattices, and magnetic memory devices. The ultimate aim of research in spintronics is the discovery and invention of new devices, such as spin transistors and their integration into semiconductor technology to create better functionality and performance at lower cost and complexity. The purpose of this research is to explore circuit techniques for spin-based devices that are suitable for nonvolatile memory applications, replacing conventional memory technologies such as DRAM, SRAM, Flash, and EEPROM. The basic structure of a spin-based memory cell is a magnetic tunnel junction (MTJ) that consists of two ferromagnetic layers separated by a thin layer of insulating material. One of the two ferromagnetic layers is a thick layer whose magnetization is fixed. The other one is a thin layer, also called free layer, whose magnetization can be switched so that its direction either parallel or anti-parallel to that of the fixed layer. This corresponds to storing a digital 1 or 0 in the cell. Reading the stored bit is achieved by examining the resistance of the cell. This resistance is low for the parallel state and high for the anti-parallel state. There are several challenges in the operation of the MTJ device that must be addressed before the spin-based memory can compete with the current technology. These challenges include the ability to store more than one bit per cell, the ability to scale the cell size and the ability to make the cell's operation faster and more reliable. The goal of this research is to devise circuit techniques to circumvent these shortcomings and ease the requirements for the underlying technology.

High-Speed Wireline Signalling  
[www.ece.utoronto.ca/~ali]

This research targets circuit design for high-speed chip-to-chip signalling, backplane signalling and optical communication. This includes circuit designs for the transmitter (such as the design of MUX, equalization and driver) and the receiver (such as adaptive equalization and clock and data recovery). At speeds beyond 1 Gbps, even a few inches of a PCB trace acts like a transmission line and as such exhibits frequency-dependent attenuation, signal reflection, crosstalk and timing jitter. The goal of circuit design in this area is to compensate for the channel attenuation, reduce signal reflections and reduce crosstalk and timing jitter so as to reduce the bit error rate (BER) of the communication link while using less than a few mV/μsec of power per Gbps operation.

Smith, Peter W. E.  
[www.ece.utoronto.ca/~pwe]

My teaching and research interests have centered on the study of ultrafast photonic and nonlinear optical effects in materials, and on the development and characterization of ultrafast optical devices for all-optical switching and signal processing. A number of materials systems have been investigated, including bulk and composite semiconductor materials, semiconductor optical amplifiers, organic polymers, inorganic crystals and colloidal semiconductor nanocrystals. We have found that with suitable preparation and treatment, many of these materials can be made to exhibit large optical nonlinearities with very rapid (pico- or sub-picosecond) response times. Such materials will form the basis for a new generation of ultrafast all-optical signal-processing devices. These devices, because they operate at ultrashort rates in the optical domain, will eliminate the “electronic bottleneck” that limits the capacity of current-day data communications systems.

Sousa, Elvino  
[www.comer.toronto.edu/~sousa/sousa.html]

The research focuses on our vision for 4G wireless networks. This vision stresses the deployment aspects of the physical layer, including features that allow the physical layer to autonomously configure itself after the deployment of basestations or access points by users. The basestations and access points are deployed by users in a random manner and the network infrastructure is built and grows organically.

Steffan, Gregory  
[www.eecg.toronto.edu/~stefan]

We develop compiler and analysis tools for making modern multiprocessors easier to program. In particular, we are investigating support for optimistic parallelism and transactional memory, with a current focus on parallelizing C++ applications.

Stumm, Michael  
[www.ece.utoronto.ca/~stumm]

Our primary objective is to make improvements to operating systems that significantly improve kernel and application performance. Currently, we are primarily targeting multiprocessor systems. Our general approach is to exploit Hardware Performance Counters (HPCs) that today are in integral part of all processors, and use them to measure overheads and identify bottlenecks online and in real time. We then feed the information gathered from the HPCs to the system resource managers so that they can make informed decisions on how best to use system resources from a performance point of view. Using this approach, we recently introduced a new system called to Linux that improved the throughput of Apache by over 100% without any modification to Apache and we improved the throughput of MySQL by 40%.

Tate, Joseph (Zeb)  
[www.ece.utoronto.ca/~zeb]

The rapid increase in variable generation technologies such as wind and solar power throughout many nations’ power grids has the potential to significantly reduce reliability. To ensure this does not happen, power companies must run a multitude of simulations that identify potential problems before they occur in the real system. The ability of these simulations to accurately inform decisions is only as good as...
the models being used and the lack of confidence in dynamic models is one of the main problems associated with these new-generation technologies. For several reasons — such as model order reduction to make simulations tractable, the reluctance of generator manufacturers to release detailed models or parameter sets and the relatively high in-
stallation of wind generation — the accuracy of wind generator models is becoming increasingly important to planning engineers.

This project is looking at ways to use ambient wind power generator measurements (i.e., without introducing artificial stimuli to the system) to determine wind parameter models for use in simulation-based studies. Thus far, we have been exploring the performance of various nonlinear parameter estimation schemes, in particular the Extended and uncorrelated Kalman Filters (EKF and UKF respectively), to select the most appropriate algorithm for this application. We have seen via simulation with high-fidelity models that, for a relatively simple DFIG model, the UKF is generally superior to the EKF in both robustness and speed of convergence, confirming the UKF’s superior performance when applied in other disciplines. Two extensions are currently being investigated: first, the impact of reduced bandwidth sampling (e.g., using 30-60 samples per second) and second, testing of the UKF estimator with acmeasurements.

Taylor, Josh

It has never been possible to provide electricity with 100% reliability; this will become even more of an issue as we increase our reliance on volatile renewable sources of energy like wind and solar. Demand response programs incentivize loads to modify their electricity consumption to accommodate uncertainty in the power supply. For example, if a building owner could be induced to reduce electricity use for allowing their air conditioning to be shut off a few times per year, relieving a stressed power system on the hottest, most demanding days of the summer, demand response has many advantages: low infrastructure cost and fast response times, but presents a number of new challenges because the number of electric loads dwarfs the number of traditional generation resources, and the characteristics of each load are fundamentally uncertain. For example, the state of a load may change as a function of weather, existing hardware compo-
nents, or the people who use it. In a demand response program, each time a load is shifted, new information about it becomes available. In this project, we investigate how load aggregators can improve their capabilities by factoring learning into their demand response algorithms. The problem is both very large in scale and high-
dimensional in its uncertainty, necessitating approximations with the highest tractability.

Learning to Manage Electrical Loads

Trescases, Olivier

Battery Management for Electric Vehicles

www.ee.utoronto.ca/ o/it

Despite numerous technological innovations, the penetration of EVs in Canada is primarily limited by the range and cost of today’s vehicles. Reducing the cost and extending the range of EVs is a major multipl-
cipinary challenge faced by the global automotive industry. Advances in lightweight materials, battery chemistry, battery management and power electronics are needed to meet future customer expectations and convert electric vehicles into a mainstream general transportation technology. Another major hurdle in wide-scale acceptance of EVs is the uncertainty in the lifetime and reliability of the battery pack, especially in the harsh Canadian climate. This has delayed the adoption of lithium-ion (Li-ion) based battery technology until very recently despite vastly superior energy density compared to the Ni-MH batteries used in the first generation of electric vehicles. Making better use of the energy capacity by increasing the system efficiency is the key to reducing the overall size and cost of the EV battery. Regenerative braking (Regen) is often used in electric vehicles to capture kinetic energy that is otherwise wasted in the brake pads when the vehicle comes to a stop. Instead of simply applying the mechanical brakes during deceleration, an EV equipped with a Regen system uses the motor as a generator in order to transform mechanical energy into stored charge in the battery. Even the latest lithium-based batteries have a relatively poor energy density to quickly absorb vulnerabilities, which could potentially lead to new disasters like the California Electricity Crisis. It is therefore imperative that power markets be systematically designed to induce fair and honest participation among market participants. In this project, we apply game-theoretic tools to assess the vulnerabilities of power markets, and use mechanism design to develop countermeasures that ensure market participants do not have incentives to game the system. For example, by examining the equilibrium of a dynamic game model of energy storage markets, we can see if tactical behaviors can lead to poor social outcomes. Tools like the Vickrey-Clarke-Groves mechanism enable us to make such tactical behaviors unattractive by imposing auxiliary payments like an upfront tax.

Gaming in Modern Electricity Markets

www.ee.utoronto.ca/ o/it

Taylor, Josh

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dimensional in its uncertainty, necessitating approximations with the highest tractability.
As the world faces unprecedented environmental challenges, energy efficiency and power management have become top concerns. Switch-mode power supplies (SMPSs) are key enabling technologies for efficiently delivering the tightly regulated supply voltages required by today’s modern mixed-signal (digital/analog) integrated circuits (ICs) and systems. The SMPS acts as the interface between the energy source, such as a battery and the load ICs. A typical SMPS uses a combination of high-speed, low-resistance semiconductor switches, energy storage components, sensors and control circuits to regulate one or more output voltages in the presence of disturbances. State-of-the-art SMPSs have a power conversion efficiency above 90%. The resulting low heat dissipation allows multiple SMPSs to be integrated with their load circuits into a single IC. The clear trend in SMPSs research is toward adaptive digital control loops, increased integration within system-on-chip (SoC) applications, higher efficiency over the full operating range and higher switching frequency, resulting in smaller energy storage components.

The long-term goals of this research are to develop tomorrow’s power management systems smaller, more efficient, more robust and more reliable, while reducing electromagnetic interference (EMI) and environmental impacts. Our group focuses on high-frequency power electronics, thermal management, low-power mixed-signal circuits and power MOSFET optimization. Electric lighting accounts for approximately 11% of the world’s total power consumption. The development of cost-effective power management circuits for compact fluorescent bulbs (CFLs) has led to drastic improvements in lighting efficiency. While CFLs are clearly an improvement over arcandescent incandescent bulbs, they are difficult to dim; they contain poisonous mercury and the chromatic properties of the light are less than ideal. High brightness (HB) LED modules are rapidly emerging as a promising candidate to replace CFLs in solar powered systems.

Solar energy has long been recognized as one of the most abundant forms of clean renewable energy. Countless research efforts around the globe are contributing to the steady decline in the cost of photovoltaic (PV) power, with the promise of reaching grid parity in the near future. This is a complex target, as the prices of conventional energy sources are constantly in flux and heavily dependent on government policies. The lighting efficiency and chromatic properties of HB-LED systems using closed loop thermal and optical feedback. The targeted controller can efficiently regulate the electrical-to-optical energy conversion process under a wide range of operating conditions for different levels of granularity and to develop new high-efficiency power electronic converter topologies and control schemes for both monocrystalline silicon and multijunction Si-PV systems.

Valasek, Shahrak Location of Wireless Terminals in Indoor Environments

Location-based services (LBS) are emerging as new applications on mobile phones. In LBS, the main challenge is to locate the user, especially in indoor and covered areas where GPS service is not available or has unacceptable errors. In this research, we estimate the location of a mobile phone using the strength of signals arriving from Wi-Fi access points. We have designed and deployed on the campus of the University of Toronto. In a shopping mall, in a university building, and in the Canadian National Institute for the Blind (CNIB). The system has a tracking and navigation system that uses voice instruction to help visually impaired individuals to find their way in indoor environments.

Wireless Communications in Vehicular Environment

In 2000, an estimated 6,394,000 motor vehicle crashes were reported to the police in the U.S. Based on a series of in-depth investigation of police reports on scene investigations, human factors have been shown to be the definite cause of 70% of the crashes. Most of these accidents could have been prevented if devices that allowed unattended phones and PDAs and have tested it in an office building at the University of Toronto, in a shopping mall and in north Toronto in the Canadian National Institute for the Blind (CNIB). The system has a tracking and navigation system that uses voice instruction to help visually impaired individuals to find their way in indoor environments.

Triverio, Piero Electromagnetic Transients in Power Distribution Networks

Power distribution networks. Lightning, faults and switching activity can induce fast transients on power networks, potentially compromising grid stability. As network complexity increases, because of the penetration of renewable sources and high-voltage underground and submarine cables.

Modelling and Simulation of Complex Systems

Numerical techniques for the simulation of complex systems are a standard tool in many scientific and industrial projects. However, computational complexity is often a big issue. Our group develops techniques to generate compact models for highly complex components based on system identification and model order reduction. Models can be extracted from high-fidelity simulations or experimental results and enable a fast simulation of large-scale systems. This approach has been applied to the design of high-speed circuits and to the thermal simulation of 3D integrated circuits with liquid cooling.
Venetis, Andreas

**Research Title**: Digital Signal/Image Processing, Digital Communications, Biometrics and Biomedicine

**Research Focus**: In digital signal/image processing our work is contributing to both digital communication circuits and systems based on mm-wave DACs. This research focuses on the development of new high-data rate wireline communication circuits and systems operating from DC to over 55 GHz. The circuits will be fabricated in the world’s most advanced 28-nm FD-SOI technology.

**Group Focus**: The group focuses on the development of CAD software that expedites the extraction of the noise parameters of 400-GHz SiGe HBTs in the virtually uncharted 100–500 GHz band. This research focuses on developing characterization, modeling and design methodologies, as well as circuit and system architectures for future integrated systems operating in the virtually uncharted 100–500 GHz band.

**Research Areas**: The lab that has already been demonstrated in the lab are (1) 120-GHz and 150-GHz high resolution position sensors with 0.05° and in-package antennas fabricated in a 65-nm CMOS process, and (2) a 110-Gb/s radio transceiver array with 16 antennas operating as a 40-GHz radio and as a Doppler radar. (3) A 165-GHz passive imaging receiver with sub 0.3 K temperature resolution and consuming 85 mW and (4) 200–300-GHz low-noise signal sources and amplifiers.

Wong, Willy

**Research Title**: Sensory Neuroengineering

**Research Focus**: My interests are in the areas of neurosciences, signal processing and sensory engineering, with particular application to speech and hearing. My work lies at the intersection of biomedical, computer and communications engineering. Students working in my group typically have an interdisciplinary approach with interests in signal processing, algorithm design, modeling and psychology. Currently I engage in three active project areas: (1) Theoretical studies of sensory information processing. We are developing a physics-based model of the process by which the sensory system transmits information from periphery to the brain. The goal of this project is to elucidate the underlying physical laws that govern the process of sensation; (2) Biomedical signal processing. We work with a team of doctors and surgeons, using signal processing and data mining techniques to better understand and diagnose neurological disorders like schizophrenia or major depressive disorder. We are also engaged in invasive neuroscience for rehabilitation applications; (3) Acoustic and speech processing. We focus here on problems related to speech and hearing loss and the tools that we can develop to aid those with communication disorders.

Wonham, Murray

**Research Title**: Supervisory Control of Discrete-Event Systems

**Research Focus**: Our research is on supervisory control of discrete-event systems, that is, logic control of systems described in a framework of automata and formal languages. We focus on system architecture and “intelligent” computing techniques as a means of confronting space-explosion and exponential complexity. Specifically, architectures include monolithic (as a “worst” case), refined to decentralized, distributed, hierarchical and their combination as heterarchical system architectures and industrial diagnostic systems.

Yoo, Paul

**Research Title**: Electrical Neuromodulation for Bladder Dysfunction

**Research Focus**: The objective of this project is to develop a neural prosthesis for restoring bladder function in individuals with neurological or idiopathic disorders. This involves: (1) the investigation of neural mechanisms underlying various stimulation-evoked bladder reflexes; and (2) the development of minimally-invasive methods of electrically engaging these neural pathways; and (3) the clinical translation of these technologies in patients with chronic urinary dysfunction.

Harel Shouval
U Texas Medical
Reverse Engineering
the Cellular Basis of Learning and Memory
October 3

Ray Liu
University of Maryland
Green Wireless Communications: A Time-Reversal Paradigm
October 10

Kameshwar Poolla
UC Berkeley
Modeling, Control, and Optimization: Critical Technologies in Semiconductor Manufacturing
November 14

Peter Asbeck
UC San Diego
Pathways to Power with Micro- and Millimeter Waves
January 9

Jason Nieh
Columbia University
Virtual Smartphone Computing
December 5

David Perreault
MIT
In Search of Powerful Circuits: Developments in Very High Frequency Power Conversion
January 23

Nass Shroff
Ohio State University
Low-Complexity Scheduling Policies for Achieving Throughput and Delay Optimality in Multi-Channel (OFDM) Downlink Systems
February 27

All talks are held at 3 pm in room 1105 of the Sandford Fleming Building, 10 King’s College Road, University of Toronto.

www.ece.utoronto.ca/about/distinguished-lectures