momentum

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Mechanical & Industrial Engineering
University of Toronto

Issue 4
Engineering Smart Cities

“Smart cities are not very smart if they ignore or disenfranchise any portion of their citizens.”

Issue 4
Engineering Smart Cities

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"The work of our researchers today is far reaching, life changing and forward thinking."

Message from the Chair

Throughout my two terms as Chair of the Department of Mechanical & Industrial Engineering, and in my 22 years as a Professor at this esteemed department at U of T Engineering, I have continually been amazed at the research achievements of our faculty.

The work of our researchers today is far reaching, life changing and forward thinking. That is why it is an honour to share the stories of their incredible research advancements with you in our fourth issue of *Momentum*.

In this issue, we focus our attention on the topic of cities. As city populations in Canada and around the world continue to swell and age, as needs of city dwellers evolve, and the health of our planet raises new challenges, the role of the engineer becomes a vital part of finding solutions – especially mechanical and industrial engineers.

As you will read in this issue, our researchers, graduate students and alumni are engineering smart cities: optimizing Toronto's health care system; improving agriculture and emergency response needs in international cities; and, innovating and addressing the needs of cities 25 years from now.

At the Department of Mechanical & Industrial Engineering, our research excellence is not our only point of pride. Our department continues to strive for excellence in education as well. After all, the health of our future cities will rely on the engineering talents of our graduates. We have so far graduated 12,000 alumni who make significant contributions to communities and cities, and we look forward to graduating more for years to come.

This new issue also comes at the conclusion of our celebration of 125 years of mechanical engineering at U of T. It also comes at the heels of 55 years of industrial engineering. These milestones are an opportunity to reflect on our achievements and to thank you, our esteemed alumni, for your continued support.

I hope you enjoy and share the stories you will read in this magazine, and encourage you to continue reconnecting with us at future events at the Department of Mechanical & Industrial Engineering.

Jean W. Zu
Professor & Chair

Safer Healthier

Redefining Smart Cities in Asia

By Brian Tran


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IDEAL PRODUCTS
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IDEAL PRODUCTS
Your Dream... Our Commitment
Cleaner
Richer

From the overcrowded motorways of Dhaka to the slums of Mumbai, our MIE students and researchers are making cities better places to live for millions of people in developing economies of Southern Asia.

Worst Place in the World to Need an Ambulance

When emergency sirens blare, cars yield. At least that's how it works in Toronto. Not so in Dhaka, as industrial engineering PhD student **Justin Boutilier** discovered during his three-week adventure in September 2015, in Bangladesh's largest city.

For starters, Dhaka has no public ambulance service. For the private ambulance services that do operate, there is nowhere for nearby cars to pull over in the city's notoriously congested roads. As Boutilier experienced firsthand, travelling a few kilometres by car within Dhaka can take hours.

This means that for the city's 7 million residents, getting emergency medical treatment is no easy feat. During his data collection, Boutilier discovered that, "Ambulances are one of the least-used methods to get to the hospital. The most common method by far was by rickshaw. It took some people hours to get to the hospital. That was pretty shocking."

Boutilier, working under the supervision of Associate Professor **Timothy Chan**, is seeking to change this. His approach uses traffic and patient location data to create a model of how to optimize ambulance service in Dhaka. His goal is to help operators to position their fleet of vehicles in the most injury-prone areas of the city to minimize ambulance arrival times, and when the need strikes, to take the most efficient route to minimize travel times to hospitals.

Boutilier hopes that his research will lead to fewer preventable deaths. He's optimistic that his optimization approach to smarter ambulance management can be applied to other large cities in South Asia where congested roads pose formidable challenges to reaching sick and injured people.

Tuberculosis Should Be Very Afraid

Canadians can be forgiven for thinking that the war on tuberculosis (TB) has been won. But in many parts of the world, the lung-destroying disease remains a killer. As recently as 2013, 9 million people worldwide contracted TB. An astonishing 1.5 million people died of the illness that year – more than the entire population of Manitoba.

Assistant Professor **Edmond Young** hopes to make detecting TB faster, cheaper and more reliable in cities like Bangkok. Using plastic chips containing small recesses to store bacterial samples and chemical dyes that change colour in the presence of the bacteria, Professor Young's TB diagnostic toolkit could allow health service

Justin Boutilier spent three weeks in Dhaka, Bangladesh researching local traffic patterns using a smart phone app in order to better understand how ambulances should be deployed.

providers to confirm the presence and drug resistance of the disease within 24 hours. Densely populated cities like Bangkok are at heightened risk of TB outbreak. A lab test can take up to four weeks to confirm and equipment isn't always available. A skin test, routinely used in developing countries, takes only two days but is less reliable.

This is why Professor Young's TB-detecting chips are needed. He believes that the affordability and simplicity of his fabrication method will help resource-strapped hospitals to adopt the chips.

"One of the objectives of the study was to fabricate them at a high enough production level to demonstrate scalability. We were able to make a hundred chips in a month just in my lab alone with very minimal resources," says Professor Young.

Professor Young's lab tests on inactive TB samples in 2015 showed promise. He's taken his prototype to colleagues in Bangkok to test using living TB bacteria. With field studies within view, the world could one day have a new powerful weapon to combat TB.

Water, Water Everywhere

Audiences around the world caught a glimpse of life for India's urban poor in the 2008 film *Slumdog Millionaire*. As three industrial engineering students discovered during their November trip to Mumbai, where the film takes place, limited access to water, exposed sewage and high population density together spell a sanitation nightmare.

For their fourth-year capstone project, **Lauren Howe**, **Amanda Persaud** and **Eashita Ratwani** – under the supervision of Professor **Mark Fox** – are designing a modular hygiene facility to improve sanitation for millions of people in India. Their project took them to the heart of two of Mumbai's slums, Dharavi and Santacruz, where they observed firsthand the squalid sanitation conditions they were tasked to improve.

Their work is helping Biopolus, a clean technology company based in Budapest, to design a self-contained sanitation block that can be rapidly deployed in countries where such infrastructure is inadequate. The company hopes these blocks will provide needed toilets, showers and laundry facilities.

Howe, Persaud and Ratwani quickly discovered that their greatest engineering challenge wasn't the technical design of the modules, but to instill a sense of local ownership, "If people don't respect the facility, they won't clean up after themselves. They simply won't take care of it. If they have respect for it though, they will treat it as their own," says Howe.

"The next step is to transition and scale the technology into a sustainable business model for aquaculture operators in Southeast Asia"

Graduate students Shakya Sur, Ahmed Mahmoud, and Professor Amy Bilton installing their passive aeration device in a test pond in Vietnam.

The students gathered data through focus groups on how best to design air circulation fans, washbasins and basic locking mechanisms to suit the needs of residents. They believe their greatest contribution, however, will be to develop implementation guides on how to win community support where the sanitation blocks could one day be built.

Fresh Air Will Do You Good

Construction cranes are a familiar sight in the Vietnamese capital of Hanoi. The city has experienced breakneck economic growth since Vietnam opened its doors to world trade in the late 1980s. To feed the country's increasingly prosperous population of 94 million people, fish, an important source of protein in people's diets, must be abundant.

Assistant Professor **Amy Bilton** is leading a project to increase oxygen levels in aquaculture ponds to increase fish farm yields. With her research team, she is building a floating device that uses solar thermal energy to heat a portion of the pond bottom to induce circulation through buoyancy and conduction principles. The result is higher oxygen levels throughout the depth of the aquaculture pond, increasing its ability to sustain life.

In November, Bilton conducted field tests in nearby Bac Ninh province, a one-hour drive from Hanoi, where the device has shown the potential to increase dissolved oxygen levels by up to 30 per cent. She hopes that the technology will have an immediate impact on fish farmers.

"The first steps are to show efficacy in improving dissolved oxygen. Then we want to show impact in terms of fish growth and fish production. The next step is to transition and scale the technology into a sustainable business model for aquaculture operators in Southeast Asia," says Bilton.

While higher yields could translate to higher profits for fish farmers, the oxygen-enriched water might also allow farmers to use less feed and antibiotics, encouraging more sustainable farming practices. Widespread adoption of the technology could mean greater fish supplies to nearby cities, increasing food security for economic engines like Hanoi.

Brian Tran is a freelance writer from Toronto and founder of communications agency *Sea & Mulberry*.

OPTIMIZING TORONTO HEALTHCARE

By Daniel Rouse

Optimizing Toronto Health Care

Since the late Professor and former Chair Ben Bernholtz joined the Industrial Engineering department in 1962, the University of Toronto has had a significant influence in the city's health care.

Professor **Michael Carter** began his first tentative steps into health care via research as a student in 1973, but it was in 1990 – after nine years in Toronto – that he realized organising health care in the GTA and beyond was a herculean yet requisite task.

"I was doing this project 26 years ago with Professor Linda O'Brien-Pallas from U of T Nursing, and we worked on simulating surgical patient flow at five Toronto hospitals. It was during the course of that time that I discovered how seriously bad things were from a process perspective. There literally was no process, so I decided to devote my research to the health care centre," says Professor Carter.

In 1994, he began teaching a fourth-year course called *Healthcare Systems* to educate engineers on the challenges and the opportunities in the area. More than 700 students have taken the course, and many have been inspired to look for careers in health. He has supervised 183 students on health care-focused capstone projects and 72 graduate students specializing in health care research.

"I have a list of close to 100 former students I know who have been hired in health care in Toronto. They are in most of the large hospitals, health agencies, consulting firms and the Ministry of Health," adds Professor Carter.

In 2008, he founded the Centre for Healthcare Engineering to support research, teaching and service. The Centre has been involved in dozens of high-profile projects, where nowadays Carter explores and implements many nationwide policies in the health care industry. He also conducts further meticulous research to help manage the resources of Toronto hospitals, and his influence continues to be apparent in the city's health care handling and in the innovative directives forwarded by other professors under his wing.

Efficiency of operations

Along with a host of MIE graduate students, Associate Professor **Dionne Aleman** runs simulations to ensure there is optimal use of the city's operating rooms.

They found that placing surgeries with relatively set time durations at the start of the day, and those of changeable lengths of time later in the day, reduced cancellations of patients' operations at Toronto General Hospital by 20 per cent. The working days of surgeons were also looked into, with those performing more

intense procedures found to be better working at the end of the week, so patients can recuperate over the weekend when no organized operations are planned. Out-patients are better scheduled at the start of the week, to keep beds free during a busy operation week.

The long-term goal is to have hospitals working collaboratively across cities and counties. A simulation treating the operating rooms and surgeons of Toronto General Hospital, Toronto Western Hospital and the Princess Margaret Cancer Centre as one single entity proved a success.

"What we found is that we can work on the same number of patients but in about two-thirds of the time, while having much higher operating room and surgeon utilization," says Professor Aleman.

Models are being put together to mathematically optimize radiation therapy too, a project Professor Aleman has invested a lot of time into lately.

Aleman explains, "You can easily calculate how much radiation has been deposited into the area at risk. We can then just calculate analytically what our treatments would do."

The work ensures a sufficient amount of radiation is addressing a cancerous tumor, while reducing the risk to other areas of the body that don't require the therapy.

Outside the hospital

Professor Aleman is also striving to reduce the burdens on the health industry with the Pandemic Outbreak Planner.

"I had an Indonesian student who came up to me not long after the big tsunami in 2006 and said that he wanted to do some work on emergency disaster planning," says Professor Aleman.

Once again, she undertook a painstaking task of reducing countless 'what if?' scenarios to numbers. But in this quantitative world that bears similarities to baseball's analytics, she has pitched every question and covered every base. The simulation model guides those making public policy during a pandemic to have simpler choices between A and B, rather than cope with an issue that spreads beyond comprehension.

"For example, what if the vaccination plan is targeted towards kids under the age of five and people who are over the age of 60? How different is that from doing nothing or vaccinating everybody randomly?"

The simulation answers these questions.

Obviously not everyone's going to do as they're told. Should a certain scenario suggest shutting a school down for two days to avoid the spread of an illness, what's

"He's really the driving force behind health care engineering in Toronto – and arguably I would say all of Canada and maybe internationally."

Professor Michael Carter

stopping a kid from sneaking out of the back door to swing a bat with some friends?

"In our model, we have compliance rates built in for all of our policies, so we might say there's a 70 per cent compliance rate with the stay-at-home rule, for example."

The Centre for Healthcare Engineering

Associate Professor **Timothy Chan**'s work in health care has earned him the prestigious title of Canada Research Chair in Novel Optimization and Analytics in Health, meaning he is a selected recipient of government funding for his work that has, and continues to be, of vital importance to Canada and beyond.

Professor Chan is also the Director of the Centre for Healthcare Engineering at U of T, leading the university's innovative work in the data revolution impacting the health system – the directive originally founded by Professor Carter. The ambitious, ever-expanding group, which also includes Professor Aleman, aims to make health care run with the upmost efficiency. This goal, in turn, should help stem the growing costs in what is already the greatest expense for the provincial and territorial governments across Canada.

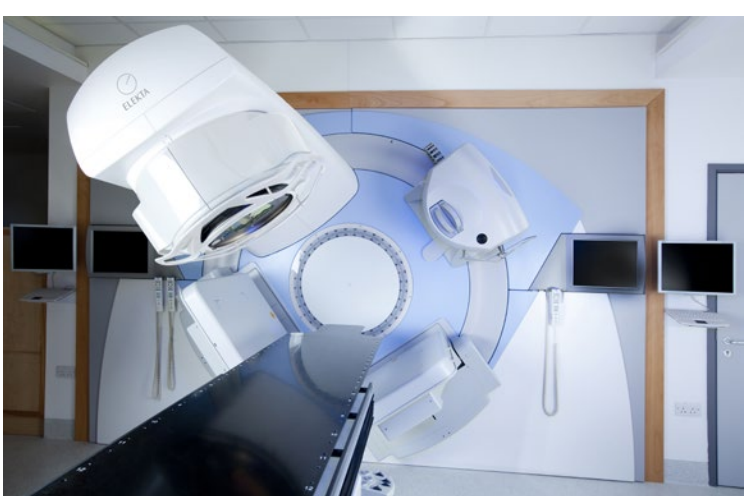
Some of the trickiest conundrums in the industry are being addressed by the team, reducing a confusing world into a manageable set of numbers and tools. In nearly eight years, the Centre has fronted various notable local and country-wide projects including helping Ontario manage surgical wait lists, forecasting nationwide demand for cardiac surgeons, and optimizing the Newfoundland colorectal cancer program.

Some of Professor Chan's latest research ties in with Professor Aleman's radiation therapy work, where they place additional emphasis on optimizing the "importance factors" of different organs when conducting the procedure, while also compensating for human factors under the beam, like if the patient moves. He has also looked into clinic scheduling in a similar vain to Professor Aleman and Professor Carter, further underlining the importance of hospitals fully utilizing their resources.

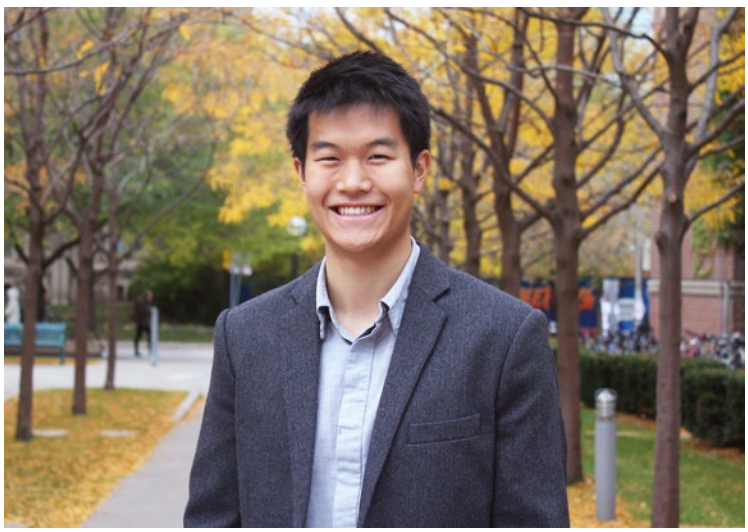
Locked out

Certain efforts to ease the management of Toronto health care are gaining mass-media attention and praise from across North America. Professor Chan and PhD student **Christopher Sun** are striving to establish a better distribution of automated external defibrillators (AEDs) throughout the city, a move that could save lives.

When it comes to determining locations to place AEDs, previous research has mainly focused on spatial factors, with a distance of 100 metres or less deemed adequate to allow treatment of a cardiac arrest within 3 minutes. However, what Sun and Professor Chan found



MIE researchers are optimizing the effectiveness of radiation therapy treatments.



PhD candidate Christopher Sun is optimizing the distribution of artificial electronic defibrillators (AEDs) in Toronto.

was that 1 in 5 of the cardiac arrests occurred near an AED that was locked away – behind the doors of buildings that had closed for business, sometimes for days at a time.

Working with their collaborators at St Michael's Hospital and Queen's University, Dr. Laurie Morrison and Dr. Steven Brooks, they were able to quantify the importance of including temporal information in the decision on where to locate AEDs. This information was then used to build a new optimization model that includes both spatial and temporal factors when deciding on AED placement. "The project started out large, so we divided it into two sections," says Sun. "Part one was establishing that temporal information is necessary, and that there is a loss in cardiac arrest coverage provided by AEDs if you don't take these factors into consideration. The second part was developing the actual optimization model, which includes temporal information, to determine AED placements."

When this was complete a previously developed spatial-only model was compared to the new spatio-temporal model, and they found that the new model boosted cardiac arrest coverage by 25 per cent.

Unsurprisingly, these findings were recognized with plenty of attention at the American Heart Association conference in November 2015, and with an award at the National Association of EMS Physicians conference in San Diego in January 2016.

MIE's influence

Ultimately, many of the projects are made possible by Professor Carter's great strides 26 years earlier, and his most recent research completes the journey from Chan and Sun's AED research.

"Today we have more than enough (cardiac surgeons), so nobody's worried about it," says Carter. "According to my models, we're running into a shortage around 2022."

It appears no stone is left unturned by Professor Carter.

"Mike has been a giant in this field for decades," says Professor Chan. "He's really the driving force behind health care engineering in Toronto – and arguably I would say all of Canada and maybe internationally.

"He knew it was the right thing to do and that engineers could make a huge impact. I think a lot of people owe their careers to him."

With around 100 graduates from Industrial Engineering now working in health care agencies, hospitals and consulting firms in the Toronto area, and with the continuous stream of students learning and researching with Professors Carter, Aleman and Chan, U of T's telling contribution in optimizing Toronto's health care – and beyond – shows no signs of slowing down.

Daniel Rouse is a freelance writer and contributor to The Score.

Honours & Awards

Alumni

International

Undergraduate Awards: Highly Commended list
Raghav Singal (IndE 1T4 + PEY)

National

Canadian Academy of Engineering (CAE): Fellow
Pu Chen (MIE MASc 9T3, PhD 9T8)
Anne Sado (IndE 7T7)

Engineering Institute of Canada (EIC): John B. Stirling Medal
Marc Rosen
(MechE 8T1, MASc 8T3, PhD 8T7)

Faculty of Applied Science & Engineering

Engineering Alumni Association Honours & Awards
Luca Casciato (MechE 1T5)
Janet Elliott
(MechE MASc 9T2, PhD 9T7)
Emil Frind (MechE MASc 6T7)

Faculty

International

American Institute of Aeronautics and Astronautics (AIAA): Fellow
Kamran Behdinan

American Society of Mechanical Engineers (ASME): Fellow
Kamran Behdinan
Hani Naguib

Institute for Operational Research and the Management Sciences (INFORMS): 2015 Moving Spirit Award
Dionne M. Aleman

Society of Plastics Engineers: Fellow
Hani Naguib

The Institute of Electrical and Electronics Engineers (IEEE): Fellow
Yu Sun

National

Canadian Academy of Engineering (CAE): Fellow
Kamran Behdinan
Jim Wallace

Canadian Society for Mechanical Engineering (CSME): C.N. Downing Award
Kamran Behdinan

Canadian Society for Mechanical Engineering (CSME): Jules Stachiewicz Medal
Sanjeev Chandra

Canadian Society for Mechanical Engineering (CSME): Fellow
Lidan You

Engineering Institute of Canada (EIC): Fellow
Kamran Behdinan
David Sinton

Government of Canada: Canada Research Chair – Novel Optimization and Analytics in Health
Timothy C. Y. Chan

Heart and Stroke Foundation: 2015 CP Has Heart Cardiovascular Award
Craig A. Simmons

The Institute of Electrical and Electronics Engineers (IEEE): A.G.L. McNaughton Gold Medal
Andrew A. Goldenberg

Professional Engineers of Ontario (PEO): Gold Medal
Cristina H. Amon

The Royal Society of Canada (RSC): College of New Scholars, Artists and Scientists
David Sinton

Award period of December 1, 2014 to December 1, 2015.

Students

University of Toronto

Distinguished Professor of Mechanobiology
Craig Simmons

Distinguished Professor of Microcellular Engineered Plastics
Chul B. Park

Distinguished Professor of Urban Systems Engineering
Mark Fox

Early Researcher Award
Birsen Donmez

Faculty of Applied Science & Engineering

Engineering Alumni Association Honours & Awards
Ronald D. Venter

MIE Early Career Award
Edmond Young

MIE Sustained Excellence in Teaching Award
Markus Bussmann

MIE Teaching Award
Craig A. Simmons

International

American Heart Association: Young Investigator Award
Derya Demirtas (IndE PhD student)

Shell Eco-marathon Americas: First Place
University of Toronto Supermileage Team; MIE members:

Callum Bartlett (MechE 1T8)
Sam Beggs (MechE 1T8)
Marina Curak (MechE 1T6)
Haya Elaraby (IndE 1T6)
Jonathan Hamway (MechE 1T3 + PEY)
Liam Keller (MechE 1T8)
Prashanth Murali Krishna (MechE 1T3 + PEY, UTIAS MASc 1T6)
Ashmith Muppalla (MechE 1T6 + PEY)
Luca Paese (MechE 1T6 + PEY)
Maxime Perreault (MechE 1T6 + PEY)

National

WISE 2016 National Conference Case Competition: First Place
Nadia Khan (IndE 1T6)
Amanda Persaud (IndE 1T6)
Eashita Ratwani (IndE 1T5 + PEY)

University of Toronto

Gordon Cressy Student Leadership Award
Marissa Goldsmith (IndE 1T4 + PEY)
Amanda Santos (MechE 1T4)
Ananya Tandon-Verma (IndE 1T4 + PEY)
Gordon Tang (IndE 1T4 + PEY)

Staff

Faculty of Applied Science & Engineering

Celebrating Engineering Excellence: Influential Leader Award
Joe Baptista

We apologize if your award is not listed. Please contact us at momentum@mie.utoronto.ca with details about your award and we will add it to our online record.

U of T Engineers are gaining new ground in an effort to build cities of the future.

By Mark Witten

THE FUTURE CITY

Twenty five years from now, we'll face an aging population, a swell of new city dwellers and an urgent need for sustainability – so will the future city be a better or worse place to live?

The Greater Toronto Area (GTA) will grow from 6.5 million to 9.4 million people over the next 25 years. The city will have nearly 50 per cent more people than today and 53 per cent of the province's population. The median age will jump from 40 to 45 and the proportion of seniors will surge from 15 per cent to 25 per cent. In 2041, Toronto will have more urban dwellers over 65 than under 15.

That's an Ontario government prediction – not science fiction.

Professor **Mark Fox** cites this scenario to highlight the kinds of challenges that a dynamic urban metropolis, with an aging population, will face: "Every city is different because it's situated in a different context. Being a smart city means you need to look at what's different about your city and the challenges it faces in the future."

"One challenge I see for a city like Toronto is how do we house and handle such large numbers of new people?"

Fox estimates Toronto will need to build the equivalent of more than 1,200 new, 50-storey apartment skyscrapers to house its surging population over the next 25 years.

"That level of building is almost unfathomable and as we increase densification, we have to find the most creative ways to increase service capacity as well," says Professor Fox, Distinguished Professor of Urban Systems Engineering and Director of the Centre for Social Services Engineering.

Will the future city Fox envisions be a better or worse place to live?

Ted Maulucci (MechE 8T9), Chief Information Officer at Tridel Corp., is part of a team applying smart technology solutions to improve the livability of the next generation of condominium communities that the real estate developer is building in the GTA.

Maulucci uses the human nervous system as an analogy to an Internet Protocol (IP) network in a condominium building.

"Most buildings today have multiple wiring systems that don't communicate with each other. A network allows multiple building systems to run on the same infrastructure for a lower construction cost, and it is an essential component that enables a wide range of

services that matter to residents on a single, integrated platform. Without a network that connects sensors and devices, you can't offer the residents the next-generation experience they would expect," he says

Good communications are also fundamental to the living experience. Maulucci gives the example of a $2-million penthouse where the owner's cell phone doesn't work because of poor cellular coverage and where the Internet connectivity and WiFi are poor.

"Would you live in a home where your cell phone doesn't work?"

Tridel continues to advance the next-generation community vision and each new community takes it one step further. The 300 Front Street community was the first to incorporate an IP network and the communities that followed started offering industry-leading Internet service.

Maulucci envisions and is working with telecommunications companies and other partners to build smart communities that can deliver, through an integrated platform, a full suite of services. Services that matter will be of value to parents of newborns and schoolchildren, single residents, seniors living independently and retirees going away for the winter.

These services will include security, energy management, and automated lockers for deliveries. It will support future online communications with pharmacists and doctors, and augmented health care services such as fall detection systems, a virtual nurse and home health monitoring through integrated and connected sensors. A digital marketplace would offer deals on local meals, dry cleaning, or in-home computer repair services.

"The smart building is a metaphor for the city. Fast and stable communications, networks connecting sensors and devices, and a common web enabled interface. We need to create places where people want to live as there is more intensification in cities," Maulucci says.

To make the city of the future a better place to live, another major challenge will be to deliver social services to vulnerable populations who need them most.

The Centre for Social Services Engineering, co-founded and led by Professor Fox, applies industrial and systems engineering techniques to improve the delivery of goods and services to the right people at the right time in urban centres.

"Smart cities are not very smart if they ignore or disenfranchise any portion of their citizens. We have a lot of latent potential voluntary resources that exist within the city. We haven't been using them for the betterment of people in the city, especially those who live below the poverty line, those living with disabilities and seniors," he says.

His Centre is developing the Social Needs Marketplace, an online resource that will integrate a wealth of services from an estimated 45,000 charities or

Smart cities scholar and University of Toronto Distinguished Professor of Urban Systems Engineering, Mark Fox.

Veronica Marin, a PhD candidate working in Professor Goldie Nejat's Autonomous Systems and Biomechatronics Lab, and "Casper" the robot. "Casper" is an assistive robot that can remind you when to eat and help with meal preparation.

non-governmental organizations (NGOs) in Ontario and make them available through a single portal.

It provides a marketplace where those who have needs and those who can fulfill them, can trade products and services. By using Artificial Intelligence methods, the Marketplace will discover what people need, and suggest what products and services best meet their requirements. He aims to integrate the social needs marketplace into existing programs like 211 Toronto, a hotline that helps people find social services.

On a broader urban scale, Professor Fox is developing through his PolisGnosis project a set of international data standards that will enable urban policy – and decision-makers to more meaningful and objectively measure and compare the performance of cities.

With the introduction of the International Organization for Standardization's (ISO) indicators for city services and quality of life, *ISO 37120* – including sustainability, energy, education and basic city services – cities are publishing vast amounts of data.

But much of this open data lacks standard formats and vocabularies to enable cross-city analysis.

"We are providing tools to automate the diagnosis and analysis of city performance. This will provide business intelligence that can tell cities why they're performing in a certain way, and understanding the reasons should help them make decisions in an evidence-based way," Fox says.

Associate Professor **Goldie Nejat** is developing and testing socially assistive robots to help meet the expanding social service needs of an aging population in urban centres. "We have a large aging population and a lot of people want to stay in the city to be close to health resources and their family and friends. The assistive robots we're developing are tools to help people age in place," says Nejat, the Canada Research Chair in Robots for Society.

Casper is a mobile, interactive personal robot Nejat and her team are designing to assist people with everyday activities in their home and live as independently as possible. Casper can find the person in the home at mealtimes, escort them to the kitchen, help choose meal options, remember where food is stored, guide meal preparation and encourage the person to eat.

"Our goal is to help people preserve their independence and their capabilities to do things like prepare regular, nutritious meals on their own," she says.

Casper interacts and communicates with the person using speech, facial expressions and a touch screen interface. "Studies with our socially assistive robots have found when natural communication is used between the robot and the person, people will actually use and accept these robots. We're trying to adapt the robot to the human and the environment, rather than adapt the environment to the robot," explains Professor Nejat, Director of the Autonomous Systems and Biomechatronics Laboratory.

In the future, next-generation robots like Casper could have teleconferencing, telehealth monitoring and linguistic capabilities to make it easier for older people living in the city to reach out to health care professionals and family members.

"Isolation is an issue in large cities and these tools can bring people together. Not all older adults are necessarily fluent in English, and multilingual robots could help translate in cities like Toronto," Nejat says.

Tangy is a social robot being designed to facilitate social recreational activities with groups of people, like Bingo or sing-a-longs, at long-term care facilities. Tangy provides encouragement, calls out the bingo numbers, helps if one of the players forgets to mark a number, and does a celebratory dance when someone wins. Such activities help to improve residents' cognitive skills such as recognition and recall, while providing a social benefit.

But the robots are also designed to assist health care professionals by doing some repetitive tasks to ease their workload, allowing them to focus on higher level tasks and give more personalized care.

"Socially assistive robots can help society and more vulnerable user groups, like the elderly, in many ways. These people have helped our society and communities throughout their working lives, and it's time for us to give them the best possible quality of life as they age," Nejat says.

The city of the future may see as many autonomous, self-driving cars on the roads as autonomous, assistive robots in condos and long-term care facilities.

Associate Professor **Birsen Donmez** is tackling the challenge of how to safely transfer control from the car to the driver, when it is scheduled, for example, to approach a highway exit, or when it is in an emergency.

"One question is, how do we warn drivers when something fails in the system and say the car starts driving into oncoming traffic?" asks Professor Donmez, Director of the Human Factors and Applied Statistics Laboratory.

Donmez's research focuses on understanding and improving human behaviour and performance in multitask and complex situations. She is developing a new driver monitoring system that continuously assesses the driver's attention and cognitive state.

"The system will use various sensors to determine in real-time whether the driver is, for example, distracted, fatigued or sleeping. Our objective is to detect a driver

"Socially assistive robots can help society and more vulnerable user groups, like the elderly, in many ways. These people have helped our society and communities throughout their working lives, and it's time for us to give them the best possible quality of life as they age."

"People in Toronto are proud of being able to get around the city without private transportation, and we need to further that so they can use sustainable public transportation to go anywhere."

state and use that information to provide timely warnings to support safe transfer of control between the car and the driver," explains Professor Donmez, who is collaborating with electrical and computer engineering Professor Kostas Plataniotis on the NSERC project.

According to recent studies, texting has surpassed drinking alcohol as the leading cause of death for teen drivers. Donmez has developed real-time, in-vehicle feedback systems for today's cars, and found in simulations and road tests that these can reduce driver distraction and improve driving performance.

"People are really dependent on smart phones and they are even more likely to use their phones in a self-driving car. We want to use this new tool to support the co-ordination between the driver and the vehicle by taking into account the tasks that are performed by the driver at any given time," she says

As cities grow and the population ages, the volume and complexity of interfacility medical transfers of critically ill patients to specialized units in hospitals in major urban centres will become an even greater challenge than it is today.

Professor Donmez developed a data-driven decision support tool to assist Ornge (the air and land medical transport system in Ontario) medical dispatchers in selecting either a helicopter and/or land ambulance as the most efficient mode of transportation in different emergency situations.

The tool can help dispatchers to make more accurate time estimates and better transport decisions in situations characterized by high time pressure and uncertainty.

"Our study found that dispatchers have estimation errors biased towards an underestimation for air transfers compared with land transfers. The estimation error for our tool was on average 21 minutes less, a substantial practical difference in urgent patient care that could save lives and lead to improved medical outcomes," Donmez says.

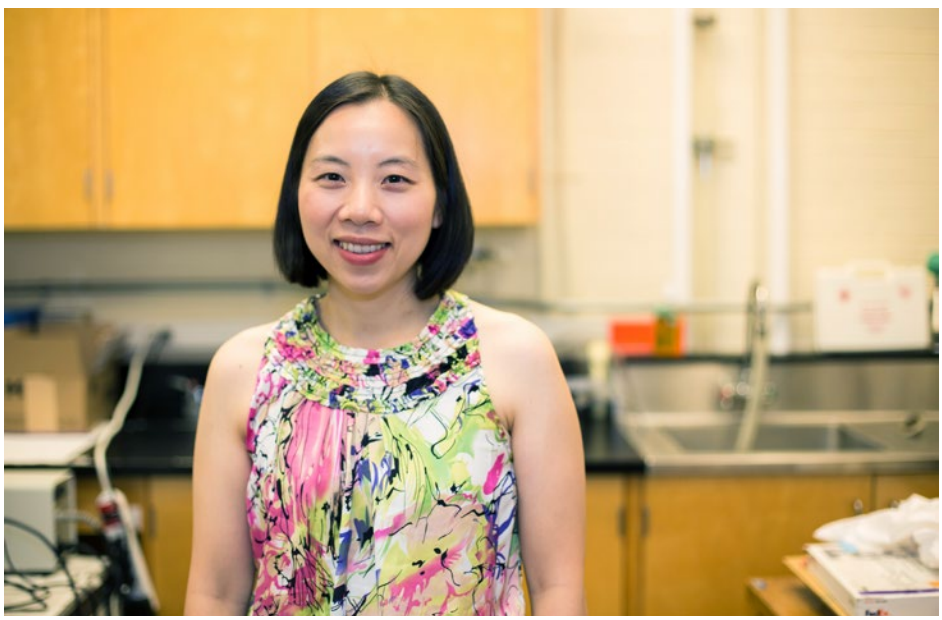
Associate Professor **Aimy Bazylak**'s research in polymer electrolyte membrane (PEM) fuel cells and electrolyzers focuses on the challenge of providing clean transportation in cars, trucks and buses, as cities become more dense and congested in the future.

She is seeking to improve the efficiency and lower the cost of these devices through advanced design of porous materials. "We're working to develop new materials for fuel cells so we can get water out more easily and get gas in more easily to improve performance," says Professor Bazylak, who is collaborating with companies like Nissan, Volkswagen and Hyundai to help advance their fuel cell development.

Because renewable energy sources, such as wind and solar, are sporadic, clean electricity must be used immediately or stored for later use. Bazylak is developing ectrolyzers that can store wind power as hydrogen for later use in fuel cells.

"The electrolyzer becomes a refueling station, which we can use to fill fuel-cell cars, trucks and buses. If we can get people to use renewable energy through fuel cells, this will reduce our reliance on fossil fuels and the emissions caused by transportation, which are very significant," she says.

Clean energy applications in transportation can help make cities better and healthier places to live in the future. "Our need for clean public transportation is only



Associate Professor Aimy Bazylak, Director of the Institute for Sustainable Energy

going to grow and we have an enormous opportunity to change our cities so people have healthier lifestyles."

"Getting people to places quickly and reliably is a key to making the city liveable. People in Toronto are proud of being able to get around the city without private transportation, and we need to further that so they can use sustainable public transportation to go anywhere," says Bazylak, Director of the Institute for Sustainable Energy (ISE).

As ISE Director, she oversees a multitude of multidisciplinary, clean energy projects being undertaken by dozens of U of T faculty and student researchers in areas ranging from biofuels and smart grids to clean combustion engines and solar energy harvesting.

She predicts that many of the solutions to the future energy and environmental challenges cities will face may be hatched by an emerging generation of researchers.

"The ingenuity and innovation coming from our students is really amazing. How the sustainable developments of the future will be shaped will come from what students want to see in their cities of the future."

Mark Witten is a freelance health and science writer in Toronto.

Facts & Figures

57

Faculty Members

441

Industrial Engineering Undergraduates (Fall 2015)

1,305

Undergraduates (Fall 2015)

864

Mechanical Engineering Undergraduates (Fall 2015)

590

Graduate Students (Fall 2015)

477

Degrees Awarded Undergraduate & Graduate Degrees Awarded (2014-2015)

70+

Invention Disclosures in the Last Five Years

10

Canada Research Chairs

12K+

Active/Living Alumni

50+

Specialized Labs

40+

UT-IMDI Industry Partners

9

Interdisciplinary Centres

4

International Capstone Projects

160+

Industry Partners

13.5M

in Total Research Funding

63

Domestic Capstone Projects

50+

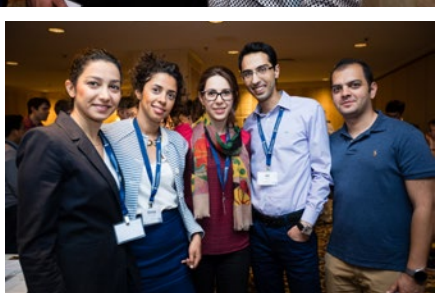
Student Clubs Financially Supported by MIE

In 2015, the Department of Mechanical & Industrial Engineering celebrated 125 years of mechanical engineering at U of T with exciting events throughout the year, bringing together alumni, friends, students, staff and faculty.

Research Spotlight and 125 Kick-off Celebration

Spring Convocation 2015

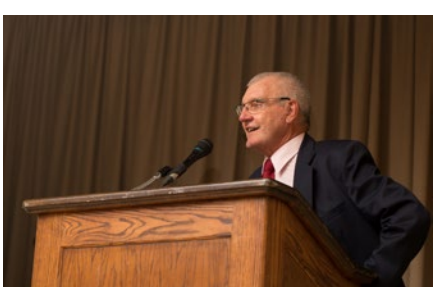
6th Annual Graduate Research Symposium and 125 MechE Celebratory Graduate Gala



Staff & Faculty 125 Celebration Dinner at Casa Loma

Your Future, Our Future

2015 Design Showcase and 125th Celebration of Mechanical Engineering



We hope you enjoyed this issue of *Momentum*.

If you have comments or questions, please feel free to email momentum@mie.utoronto.ca

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