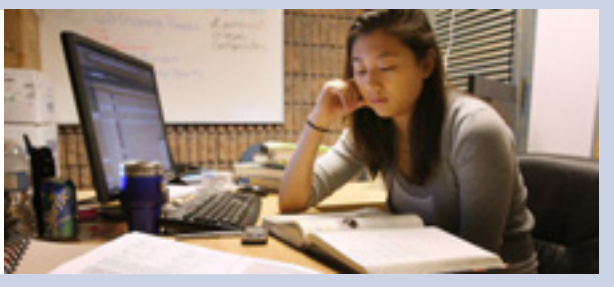
Engineers of the future

Women break into a mostly male world: Where can you study? V2



End run on censorship

Giving Syrians web access, V3

ENGINEERING INNOVATIONS

ON ON1

DISEASE DETECTION

Thinking Big in micro science

Elusive engineering professor pioneers better internal body-imaging

JUDY GERSTEL
SPECIAL TO THE STAR

John Tze Wei Yeow is a hard man to find. Try to talk to him and he's in Taiwan. Try to reach him by email and he's travelling in Asia.

It's been that way his whole life: kindergarten in Malaysia, primary school in Scotland, junior high in Taiwan, high school in South Africa, and university in Canada.

So if anybody could find a way to track down elusive organisms, no matter how difficult they are to locate, it's probably Yeow, a 37-year-old systems design engineering professor at the University of Waterloo, and the first Canada chair in micro and nanodevices.

One of Yeow's main research interests is inventing and developing tools to locate, examine and target micro-organisms lurking inside the human body, and to provide unprecedented access into its cavities.

He does this, he says, by designing devices that are "smaller, more portable, more power-efficient, more sensitive, and potentially longer-lasting."

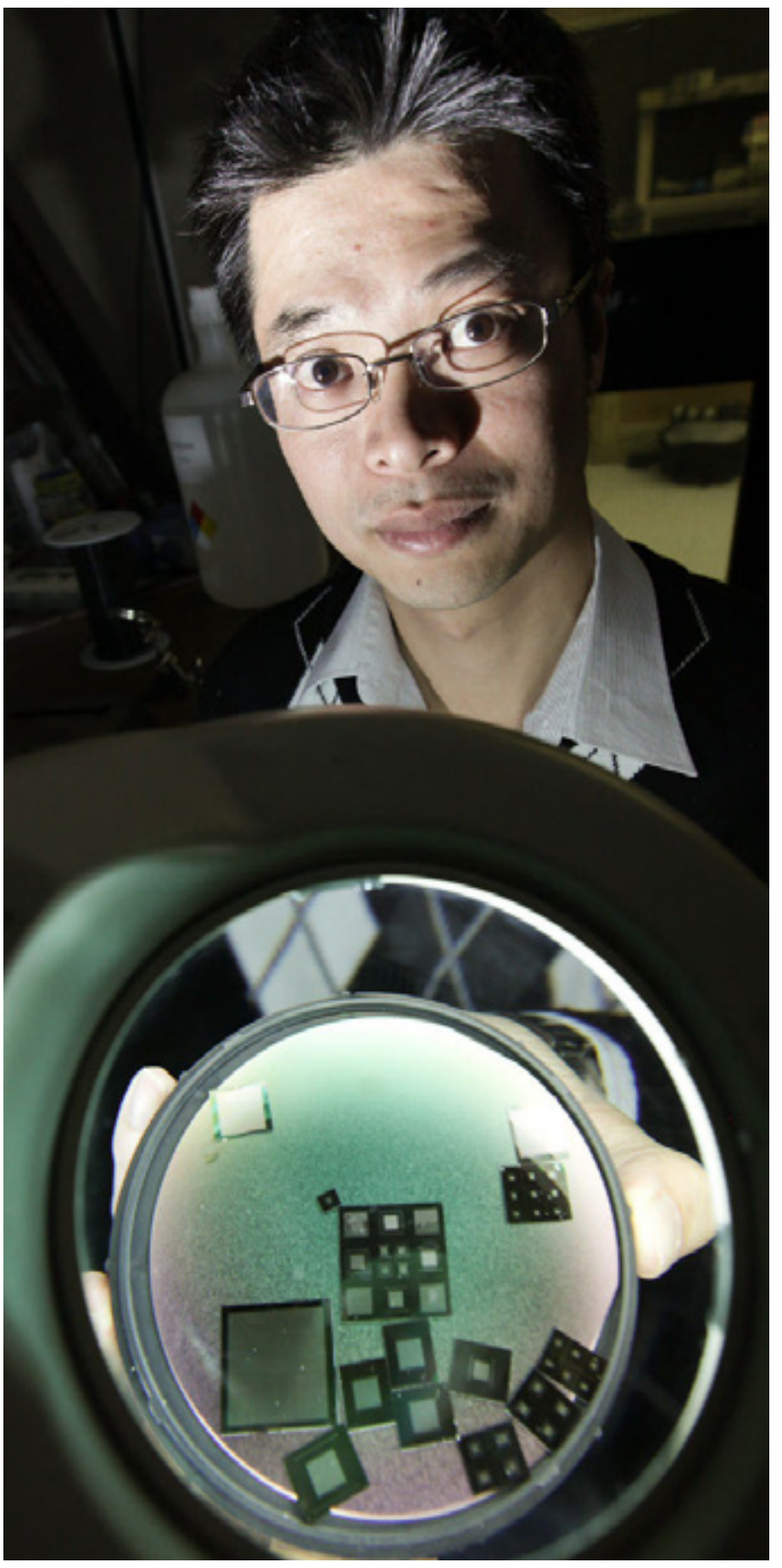
One of the most important achievements for Yeow and his team at Waterloo's department of systems design engineering is a miniaturized catheter that can make its way through the human body and provide medical practitioners with precise internal body imaging.

"Having a high-performance catheter device — smaller, (with a) larger field-of-

NANOTECH continued on V6

"Nanotechnology will have a huge impact on our daily lives in the future."

JOHN TZE WEI YEOW
UNIVERSITY OF WATERLOO



GLENN LOWSON FOR TORONTO STAR

Magnified: Chips are used in John Yeow's research into a smaller, better catheter.

INSTANT INFO

Lab on chip tests for HIV in the field

Results are delivered on the spot in minutes

CARLA WINTERSGILL
SPECIAL TO THE STAR

It looks no more complex than a supermarket scanner. But the portable lab device created by graduate researchers at the University of Toronto could radically change the treatment of HIV, by offering blood testing on the spot and producing results within minutes.

A team led by PhD candidate James Dou and his supervisor Stewart Aitchison, vice-dean of research in the faculty of applied science and engineering, is developing a handheld tool for monitoring t-cells in HIV patients.

Field-testing the "lab-on-a-chip" could begin in local hospitals as early as this summer.

"We're targeting a global challenge," Dou says.

HIV weakens the body's immune system by destroying CD4 cells, a group of white blood cells that fight off bacteria, and leaves the patient vulnerable to infection.

A crucial part of HIV treatment is monitoring the number of CD4 cells in the blood and administering antiretroviral medication as those numbers drop.

The World Health Organization recommends twice-yearly blood tests for those who are HIV-positive. In Canada, tests are conducted quarterly.

The current gold standard for CD4 testing is a machine roughly the size of a photocopier called the flow cytometer, Dou says.

Not only is the flow cytometer bulky, it's also an expensive piece of machinery that requires a trained

LAB ON CHIP continued on V2

Brian is here to help, mechanically speaking

BILL TAYLOR
SPECIAL TO THE STAR

Has anyone seen Brian's cap? He needs it for a photo-op. Even with it on, his head's not that pretty a sight. But without it, the inner workings are there for all to see.

Not gooey grey matter, but screws, wires and sensors.

Still, he has a winning smile, a "father-knows-best" stern expression, and when his silicon-rubber face falls, it could break your heart, he looks so woebegone. And they say robots don't have feelings.

That was always the great regret of Data, the android in *Star Trek: The Next Generation*.

But Brian is programmed to gauge your moods and emotions and react accordingly.

He's unfailingly polite, too, even when you've let him down.

"That makes me sad," he says gently.

"It can play memory games and card games to keep the brain active."

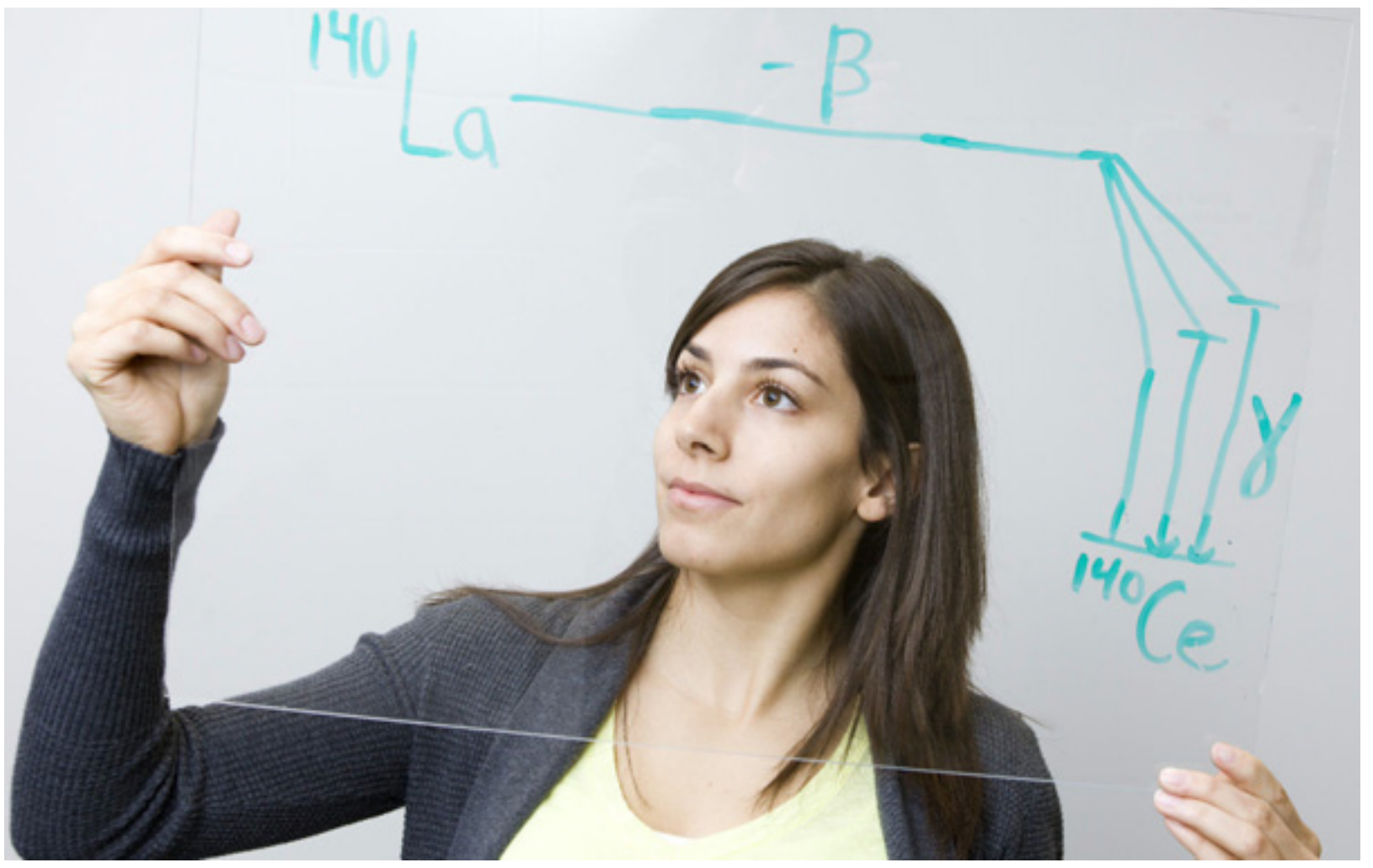
GOLDIE NEJAT,
UNIVERSITY OF TORONTO

And shakes his head.

Goldie Nejat and her team at the U of T continue to develop and refine Brian's skills. Nejat believes robots could have an important role in the care of our exponentially growing elderly population, at first in assisted-living facilities, but eventually in people's own homes.

"No one wants to move from their home," she says.

ROBOTS continued on V8



YVONNE BERG FOR TORONTO STAR

Jill Morillo, 20, examines a model of the radioactive decay of Lanthanum-140. The UOIT student believes nuclear energy is both efficient and safe.

As engineers retire, schools struggle to replace them

Attracting women to the profession is key

NICOLE BAUTE
SPECIAL TO THE STAR

When Jill Morillo isn't tearing up the rink as captain of the UOIT women's hockey team, you can find her at the library, studying nuclear reactors.

The future face of engineering may resemble Morillo's; the third-year nuclear engineering student is a natural leader with an interest in business and a social conscience. And she is a woman.

Morillo, 20, has heard good things about her career prospects: "There will always be a need for engineers, but specifically in nuclear, because our program isn't offered everywhere, we're very specialized," she says. "I've heard there are many nuclear engineers retiring."

Just when employment prospects in some professions are bleak, engineering schools are setting the brightest and best on a path to employment.

These young people will seek answers to some of the world's biggest problems: the need for renewable energy resources on a planet wracked by climate change, for computer security, for buildings that can withstand earthquakes.

Some will start businesses, while others will be hired by companies to replace skilled, seasoned engineers from the baby-boom generation, who are retiring from the workforce.

"The demand for engineering graduates is far outstripping our ability to graduate them," says Richard Marceau, provost at the University of Ontario Institute of Technology in Oshawa, and an engineer himself.

"If you look at a lot of the areas of engineering, so many of them have a bright future, because of this huge transition, this generational change that we're confronting in the next 10 years."

Marceau says between 20 and 30 per cent of Ontario's engineers are on the verge of retiring.

Opportunities lie in many areas, including civil, construction and chemical engineering.

Training new electrical power engineers should be a top priority, Marceau says. People hired during a period of rapid expansion during the '80s are starting to retire, leaving a significant gap. In 2011, between 160 and 170 positions went unfilled because there weren't enough qualified graduates — just 130 to fill about 300 jobs.

Marceau is spearheading an Electrical Power Engineering Education Consortium to try to correct the problem.

"We need to build capacity again," he says. "These are the people who keep the lights on in Ontario."

Chris Kerr, a 28-year-old engineer with Toronto Hydro, says he and his colleagues face interesting new challenges, such as finding the most effective ways to replace aging infrastructure or incorporate green energy from solar panels or wind turbines into the grid. They also strive to stay up-to-date on emerging technologies around the world, which might be useful here one day.

"They're new challenges, things that people, especially for our utility, haven't seen before," Kerr says. "It takes a little bit of out-of-the-box thinking on how we can maximize those technologies."

Today's young engineers have to be well-rounded — and have business chops.

At UOIT, Morillo is combining her engineering degree with an extra year of business management.

"Obviously business surrounds us, so to have that background, it's very applicable to almost everything," she says. She hopes to also add a one-year work placement to her degree, giving her some experience in the workplace before she graduates.

At York University, they're calling them "Renaissance engineers." York's engineering program, created in 2001, is growing rapidly. The new Lassonde School of Engineering — to be named after mining entrepreneur Pierre Lassonde, who donated $25 million to the school last fall — will be interdisciplinary, drawing on the university's strengths in law, business and the humanities.

"We want them to be known for being entrepreneurial engineers with a social conscience," says Janusz Kozinski, dean of the Faculty of Science and Engineering. "Engineering students will be exposed to business education and legal education from the outset, from year one."

Over the coming years, York plans to add four new engineering programs — electrical, civil, mechanical and chemical — and hire up to 70 new professors.

Morillo, plowing through her midterms, knows she's chosen a difficult program. "You obviously have your hard days and it is a lot of work but, at the end of the day, most of us all enjoy it and we wouldn't change into something else if we could," she says.

WHERE TO STUDY

Ontario institutes with accredited engineering degrees:
- Carleton University, Ottawa
- Conestoga College Institute of Technology and Advanced Learning, Kitchener
- University of Guelph
- Lakehead University, Thunder Bay
- Laurentian University, Sudbury
- McMaster University, Hamilton
- University of Ottawa
- Queen's University, Kingston
- Royal Military College of Canada, Kingston
- Ryerson University, Toronto
- University of Ontario Institute of Technology, Oshawa
- University of Toronto
- University of Waterloo
- University of Western Ontario, London
- University of Windsor
- York University, Toronto

Ontario colleges offering engineering technology and technician education:
- Algonquin College, Ottawa
- Cambrian College, Sudbury
- Canadore College, North Bay
- Centennial College, Toronto
- Collège Boréal, Sudbury
- Conestoga College Institute of Technology and Advanced Learning, Kitchener
- Confederation College, Thunder Bay
- Durham College, Oshawa
- Fanshawe College, London
- Fleming College, Peterborough
- George Brown College, Toronto
- Georgian College, Barrie
- Humber College, Toronto
- La Cité collégiale, Ottawa
- Lambton College, Sarnia
- Loyalist College, Belleville
- Mohawk College, Hamilton
- Niagara College, Welland
- Northern College of Applied Arts and Technology, Timmins
- RCC College of Technology, Toronto
- Sault College, Sault Ste. Marie
- Seneca College of Applied Arts and Technology, Toronto
- Sheridan Institute of Technology and Advanced Learning, Oakville
- St. Clair College, Windsor
- St. Lawrence College, Kingston

Source: Ontario Society of Professional Engineers

MORE ONLINE
- He made biodiesel from animal fats
- Using extreme freezing to preserve the catch
- Remediating groundwater

thestar.com

HIV test results less costly, too

LAB ON CHIP from **V1**

technician to operate it. As a result, flow cytometers are typically restricted to large urban centres and are inaccessible to most HIV patients in developing nations.

In Canada, those who live in remote communities must send vials of blood away to be tested. Results take up to two weeks.

By contrast, Dou's portable cytometer works like a diabetes test. A pinprick of blood is placed on the disposable cartridge and inserted into the handheld device, which counts the CD4 cells and produces results in 10 to 15 minutes.

It's also cheaper. While each test on the flow cyclometer costs $75 to $100, the lab-on-a-chip test costs $5 to $10.

Started as a graduate research project in 2007, Dou's invention is gaining traction and has garnered the attention of HIV foundations around the world.

The portable cytometer was recently recognized by Grand Challenges Canada, which awarded a $100,000 grant to team member Lu Chen, a post-doctoral fellow at the U of T. The grant will be used to test the device in Mozambique, where roughly 16 per cent of the adult population is living with HIV.

DAVID COOPER/TORONTO STAR

Dr. Lu Chen, left, Rakesh Nayyar, Lino DeFacendis and James Dou have created a portable cytometer that works like a simple diabetes test.

"The exercises go one step further than research," Aitchison says. "We know the concept works in the lab. We've got trained people loading the sample and running the software that does the counting."

Lab-on-a-chip technology has been around for a while. The real innovation comes from packaging the device in a way that allows a skilled person, such as a nurse practitioner, to use it in the field.

Dou envisions the mobile test bolstering the health-care infrastructures of developing nations by creating widespread access to CD4 monitoring.

Its adoption at home will benefit Canada's health-care system by reducing costs and wait times for testing.

It will also help improve service to vulnerable populations by taking the mobile test straight to the people who need it most.

"We want to build a commercial product," Dou says.

To that end, the team turned to the University of Toronto's Innovations and Partnerships office, which helped them establish a company to manage the business side of the product.

ChipCare Corporation will take on the commercialization plan for the cytometer.

They hope that Dou's lab-on-a-chip will spark a new high-tech industry in the city.

"If you look around the downtown Toronto core, there's a lot of good health-care research going on, but there is a lack of industry support for us to compete," Dou says.

"Canada generates as many good ideas as other countries," Aitchison says.

"But we don't translate those ideas into as many products or knowledge."

Promoting free speech worldwide

Canadian software routes access around government web filters

HANNAH HOAG
SPECIAL TO THE STAR

BLAIR GABLE FOR TORONTO STAR

Rafal Rohozinski is CEO of Psiphon, which helps activists get around filters used to control web access.

Late last year, Syrian activists found their Internet connections blocked. In need of a way to communicate, they turned to a Canadian technology company to deliver the networking system.

"The request was channelled through a number of different sources. They wanted a way of getting around Internet censorship," says Rafal Rohozinski, CEO of the Psiphon Inc.

In December, the company distributed Psiphon 3 to the activists. From his Ottawa headquarters, Rohozinski watched the number of online connections in Syria grow — to 30,000 per month. Today, Rohozinski counts 3,000 to 5,000 connections per day.

The software enabled them to tunnel past Internet filters and barriers to websites, social media and other online communications technologies.

"The act of communicating, of empowering yourself through knowledge, is an essential component of democratization," says Rohozinksi.

Psiphon grew out of an experiment at the Citizen Lab, a research and development program focused on the intersection of global security, human rights and cyberspace and based at the Munk School of Global Affairs at the University of Toronto.

In 2003, the OpenNet Initiative, a group that tracks Internet censorship, found only a few countries filtered content.

Today, it counts more than 40 countries controlling the online content that is accessed within their borders.

"When you're engaged in analyzing and tracking Internet censorship worldwide, you find out a lot about how Internet content is blocked on the Web," says Ron Deibert, director of the Citizen Lab and an investigator at the OpenNet Initiative.

Deibert says people would contact the group to find out how to bypass the censors. Although circumvention technologies existed, they lacked security or required an almost hacker-like level of knowledge to operate, he says.

The Citizen Lab set out to create software that lacked an Achilles heel.

"We had this idea of bundling together the different software packages into something simple," says Deibert.

In 2006, the Citizen Lab released Psiphon (the 'P' is silent). The first version allowed individuals to connect to the Internet through access points operated by small independent networks of trusted friends and family members.

"They could tunnel through the family member's home computer and fetch whatever content they wanted," says Deibert.

Psiphon worked because it established thousands of encrypted portals. It dispersed the connections and took Internet activity below the government's radar. A web proxy directed the censored computer to the content via an uncensored computer, not unlike the way a hockey player uses the boards to bounce a pass to his teammate.

With Psiphon, government monitors might be able to see that the two computers are connected and exchanging information, but not much else without cracking the connection, says Deibert.

In 2008, the technology was spun out of the University of Toronto and into a private company, with Rohozinksi at the helm.

The company is based on the principles that information should be free and that individuals should have the right to choose what they access on the Internet.

"But we wanted to build a company that would not have to live off of handouts from the government and academia," says Rohozinski.

That year, Psiphon responded to a tender from the U.S. State Department for censor-busting technologies, and was awarded $3 million over two years. Rohozinski says the funding launched the company, but business relationships sustain it.

Psiphon clients include the British Broadcasting Corporation and the U.S. Broadcasting Board of Governors, responsible for Voice of America and Radio Liberty.

Psiphon is used in 45 countries.

In 2009, the BBC launched a Psiphon 2 service for its Persian language website, soon after the Iranian presidential elections. It offers the same service for BBC Chinese.

Psiphon 2 shifts the burden of access from the content user to the content producer. It creates a web proxie — alternate uncensored paths to websites — and distributes them to users via social media, recorded Skype messages and targeted emails.

When someone clicks, they are directed to Psiphon servers and then on to BBC Persian content.

"The reason the BBC chose Psiphon was because of its usability," says Karl Kathuria, a fellow at the Citizen Lab and former head of digital delivery at the BBC World Service. "It keeps people inside a browser environment and it is accessible to a mass audience."

Psiphon 3, the version being used by Syrian opposition groups, adds another level of Internet censorship circumvention.

"It launches an encrypted tunnel where you can run a videochat or Skype," says Rohozinski.

It can be a cat-and-mouse game trying to stay one step ahead of the censors.

"We have to be nimble," says Rohozinski. Gathering on-the-ground intelligence keeps Psiphon Inc. ahead of the curve, as does staying technology-agnostic, making all the code open-source and using a rapid prototyping methodology.

"We develop and deploy from prototype to production within days," says Rohozinski.

CENSORS' TOOLBOX

More than 40 countries employ some form of Internet censorship. China and Iran run two of the most extensive filtering and restriction systems. They filter content that undermines the government's authority, contains political material or is deemed offensive, by employing some of the following techniques:

- Internet Protocol address blocking, which denies access to an address that hosts a website.
- DNS tampering, which diverts connections from unauthorized Web addresses to another.
- Keyword filtering, which interrupts connections to sites with keywords associated with historical events, controversial groups and other taboo topics.
- Full blocking, which cuts off all routers, as occurred in Egypt and Libya in January 2011.

Zingg gives wing to aircraft design

Computer modelling identifies promising ideas for prototypes

BILL TAYLOR
SPECIAL TO THE STAR

David Zingg loves flying and always likes to sit by the wing. It's not that he's a slave to his work, but he does take a very academic interest in what's happening out there.

Zingg, director of the University of Toronto's Institute for Aerospace Studies at Downsview, is concerned with wing configuration as part of an over-all rethinking of airliner design to reduce greenhouse gases.

The stakes, he says, are huge: "We either fly more efficiently or we fly less."

He's not thinking of the next generation of jetliner; it's the generations after that that are front and centre on his computer.

Zingg is pioneering the application of "high-fidelity aerodynamic shape optimization" to aircraft design.

His department is developing computer programs that can produce new concepts and fine-tune them before a prototype needs to be built for wind-tunnel and flight-testing.

"Obviously, you don't fly an airplane that hasn't been wind-tunnel tested," he says. "But you're no longer changing the body shape in the wind tunnel, which was very time-consuming. We can study 100 shapes in a couple of days and come up with the most promising.

"NASA, with its environmentally responsible aviation project, is doing low-fidelity assessments. There's a certain state-of-the-art in our ability to optimize these designs at a high-fidelity level. We're moving the goalposts in terms of what we can do in trying to provide the tools."

Zingg, who last year received an Engineering Medal for Research and Development from the Ontario Society of Professional Engineers, has worked closely in the past with NASA, the U.S. National Aeronautics and Space Administration.

BILL TAYLOR FOR TORONTO STAR

Prof. David Zingg's research aims to develop airliners that are more energy-efficient and cut down on emissions.

The American researchers have two generations of aircraft on their virtual drawing boards and are looking at reducing not only carbon dioxide and nitrous oxide emissions, but also noise levels.

"We're concentrating on carbon dioxide," Zingg says. "Noise, you can deal with in various ways — of course, I don't happen to live near an airport! — but global warming, there's only one way."

He says the target is a 50-per-cent reduction in emissions by 2050, which means airliners will have to be about four times more fuel-efficient.

It sounds like a tall order, but Zingg is optimistic. A study of fuel consumption and "fuel-burn per seat" since the De Havilland Comet 4 in the 1960s, shows a steady decrease of between 1 and 2 per cent per year.

"We know we'll continue that sort of rate; we'll make some progress," he says.

On the other hand, the demand for more flights goes up about 4 per cent per year.

"If we don't match or do better than that, then there'll be a choice of flying less, paying more in carbon taxes or restraints that stifle that growth," he says. "That wouldn't be good for anyone."

Research is also going into other new technologies, including biofuels.

"But sometimes people put too much hope into the role biofuels will play," Zingg says. "It's never as much, or as quick, as you hope. There's no silver bullet."

Hence the importance of his department's work. He gives a brief demonstration of how the computer does its work, taking a basic wing shape and increasing its span and adding winglets to minimize drag.

Future possibilities include different body shapes, vastly changed wing configurations and fuselages "blended" into the wings to produce a single aerodynamic surface.

There are already practical applications. The manufacturer of a small bush-plane asked the department to design a more efficient flap for the aircraft. And the flaps on the Bombardier Q400, as flown by Porter Airlines, were partially designed by a former student using tools developed here.

"We're not 'ivory tower' in this department."

The future, Zingg believes, holds a mix of jetliners even larger than current jumbos — "the blended-wing can be more efficient in big airplanes" — and smaller ones flying directly between two destinations, not via the widely used hub-and-spoke system for routing interconnecting flights.

"That's not an efficient system."

Efficiency is everything. And, somewhere within a computerized brain, there may lie a hitherto-undreamed-of-solution. The key is in unlocking that secret.

"If I was able to show a uniquely novel concept was the way to go, I'd be as happy as . . . whatever metaphor you care to use," Zingg says.

"We're still developing the tools and we always do comparison studies with existing aircraft. If something was suddenly 15 per cent better, rather than, say, 2 per cent, that would be a 'Eureka' moment. If we can do that, we might take the rest of the day off."

NEW THINKING

The jet airliner's traditional wing-and-fuselage configuration has remained basically the same for about 60 years, says David Zingg, "and there's a huge impetus to find something novel and innovative." Among the designs being considered at NASA, for possible introduction with in the next decade, are:

- Lockheed's closed-wing, which is circular in shape to cut down on drag.
- Boeing's blended wing and hull, with an aerodynamically shaped fuselage producing much of the aircraft's lift and flowing seamlessly into the wings.
- A Northrop-Grumman concept that Zingg says is "basically their stealth bomber turned into a passenger plane. That's probably a little less likely than the other two."

Building breaker? There's no sway

Rubberized dampers can make new buildings taller, slimmer and safer

STEPHEN LEAHY
SPECIAL TO THE STAR

Toronto's tall buildings like to dance in the wind, potentially making penthouse owners seasick as the tops of buildings sway by as much as half a metre.

To stop the swaying, structural engineers make taller buildings extra stiff and often plunk a concrete slab weighing 400 tonnes on the top.

Now, two University of Toronto engineers aim to design buildings that can absorb the energy from the wind, or even powerful jolts from earthquakes, with minimal movement and no damage.

"We've developed viscoelastic-energy-dissipating dampers to replace many of the heavy concrete beams used in tall structures," says Constantin Christopoulos, a professor of civil engineering and a seismic expert at U of T.

Known as the Wind-Earthquake Coupling Damper, this potentially game-changing device could first be installed in a new Toronto tower by the end of 2013.

"With the damper, buildings can offer more leasable space, be slimmer and taller, while also being safer," says Christopoulos.

Cities are going vertical all around the world. About 2,500 buildings over 30 storeys are being built or in the planning stages, according to industry statistics.

Toronto leads the way with the most high-rise buildings under construction in North America.

Concrete, and lots of it, has been the traditional engineering approach to coping with the force winds exert against tall buildings. That additional concrete adds to the cost and reduces the available occupancy space.

"Structural engineers have struggled with this problem for years," says Christopoulos, who studied earthquake engineering in California.

Ten years ago, Toronto highrise designers asked Christopoulos and other civil engineers at U of T to investigate.

"We're solving the vibration problem by damping, as opposed to stiffening, the building."

The Wind-Earthquake Coupling Damper is a multiple-layer sandwich of steel plates and viscoelastic polymer or rubber, explains Michael Montgomery, a newly graduated PhD who worked under Christopoulos to test and perfect the device.

The damper is roughly two metres long, half a metre in depth and just over a half metre wide on average, and anchored firmly to the structural walls.

When a gust of wind starts to move a building, the force or energy is absorbed by the rubber in the damper, Montgomery says. It is the combination of steel and rubber that enables the damper to soak up the vibration and yet retain its strength.

Some of the steel plates can be engineered to fail when there's a big spike in energy. These steel 'fuses' soak up the extra energy the rubber can't absorb, protecting the gravity-bearing elements of the building.

"They're designed to act like a fuse or breaker in an electrical circuit."

After an extreme earthquake, the dampers can be inspected, and, if any fuses have been triggered, they can easily be repaired or replaced.

Well-built buildings in earthquake zones rarely collapse, but are often seriously damaged. For example, nearly all the buildings that survived the magnitude 6.3 earthquake in Christchurch, New Zealand last year cannot be re-occupied without major repairs, says Christopoulos.

Repairing fractured internal concrete beams is not always possible and most of those buildings in downtown Christchurch will have to be demolished.

The Toronto team's damper successfully withstood large-magnitude earthquakes and large hurricanes simulated in testing facilities at U of T and at the École Polytechnique in Montreal.

The toughest phase of this 10-year project is to convince builders and their engineers to try the dampers, in what is a very conservative industry.

"Lots of them think it's great, but hesitate to be first to use it. It's not like trying out a new app on your smartphone," says Christopoulos.

However, one pioneering builder in downtown Toronto appears ready to make a commitment.

"We're hoping that, in the next 12 months, the first dampers will be installed."

KEITH BEATY/TORONTO STAR

PhD graduate Michael Montgomery helped perfect this wind-earthquake coupling damper for tall buildings.

NEXT STEPS

Michael Montgomery spent eight years perfecting the damper and recently won the top 2011 Natural Sciences and Engineering Research Council award for young researchers.

But he's not yet finished with the damper.

He and Prof. Constantin Christopoulos established a new company, Kinetica Dynamics, to help ensure their innovation is actually used.

"It could revolutionize the industry," he says.

Marketing even smarter memory

Engineer's Eureka moment garners financial support from a network of backers

PAUL DALBY
SPECIAL TO THE STAR

AARON HARRIS FOR TORONTO STAR

Ibraheem Khan's discovery in smart materials or shape memory alloys has the potential to change aerospace design radically.

Ibraheem Khan, a Toronto taxi driver's son, was bitten by the engineering bug as a kid, when he took apart all his new toys to see how they worked.

Years later, as a 29-year-old mechanical engineer, he made a startling discovery in the mysterious world of "smart materials" or shape memory alloys (SMAs), which many experts believe can revolutionize aerospace and automobiles.

A network of federal and provincially funded non-profit agencies has already ushered Khan and his innovation to the first rung of commercialization (see fact box).

Khan remembers only too well the day he made his big discovery. It was a cold winter's night at his parents' Mississauga home, and, as part of his PhD at the University of Waterloo, he was scrutinizing his research data for maybe the 10th time.

Shape memory alloys, which are combinations of metals, such as nickel and titanium, gold and cadmium, were discovered back in the '60s. They change shapes when exposed to different temperatures.

"I realized the data I was reading showed a blip that indicated there was a second memory embedded into what should have been a single-memory alloy," Khan said. "I guess it was a Eureka moment, so I drove all the way to Waterloo that night to prove it. We really had a single material, but with multiple memories.

"I won't say I was going above the speed limit . . . but I was moving swiftly."

Khan discovered he could embed several memories in the same smart material, enabling it to remember a series of shapes when exposed to different temperatures. He'd made the breakthrough that had evaded scientists for a decade: how to make the smart material smarter still.

The potential for his innovation is huge. For example, Khan says motors would no longer be required to control flaps on airplane wings, which would reduce the aircraft's weight and save money on fuel and construction costs. In the healthcare field, the technology could control how much a stent opens a vein or improve the efficiency of a pacemaker, brace or hearing aid.

A brilliant breakthrough, but how to get it out of the starting gate and to market?

"An engineer is not usually equipped to take it to the next level," said Khan. "But we're very fortunate to have all these institutions and support in Canada to help us to do just that."

Together with his two partners, including his university professor Norman Zhou, Khan has formed a company (www.smarteralloys.com) and connected with Bombardier as an entrée into the aerospace industry.

The involvement of industry is critical. Bombardier, which provides $20,000 to engineers for an advance concept like Khan's, believes it is a sound investment in the future.

"It's all about how we mentor a new generation of engineers," says Bombardier's Jonathan Hack, who works with universities and government to develop this talent. "We have a tremendous need for new aerospace engineers over the next five to 10 years and there is a great future in aerospace."

That link between industry and universities was also evident to Queen's graduate student Nate Preston, now 23, as he supervised a group of 50 students from Queen's, Carleton and Algonquin College to build their revolutionary solar home.

Still a year from actual construction, the finished house will represent Ontario against 20 other world-renowned universities at the prestigious solar competition run by the U.S. Department of Energy in California in 2013.

"It's a big complicated project, which needs a lot of capital resources to get it off the ground, and companies in engineering have been terribly supportive," Preston said. "They see this not only as a great opportunity to promote sustainability, but also as a chance to work with students who are highly motivated and bright."

Preston says the modular home the team is designing will not only be a building that uses only as much energy as it collects, it will offer an attractive lifestyle in a modest 1,000 square feet.

"We can't be building Ferrari homes that nobody can afford, so there is a real balancing act that goes on," he said. "Team Ontario is building attractive, comfortable homes, and we really think there are a lot of opportunities out there, and we want to inspire the public to demand more from their homes."

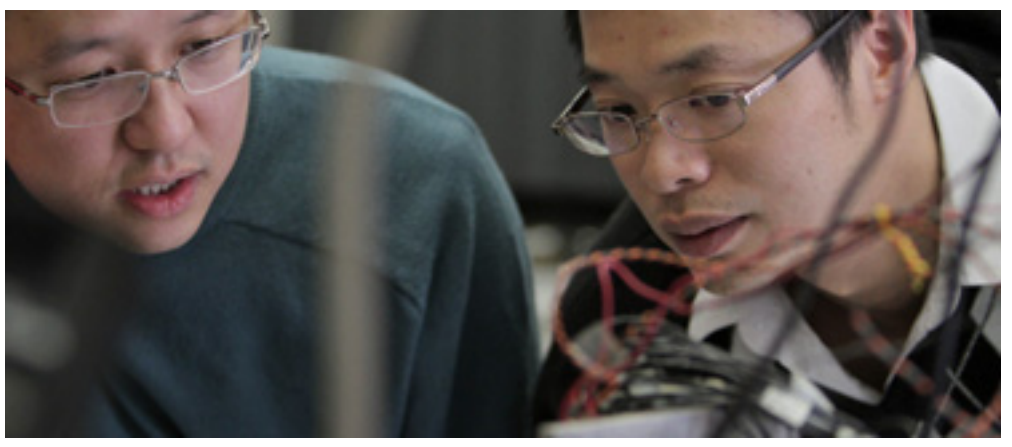
INSTITUTIONAL SUPPORT FOR GOOD IDEAS

Ibraheem Khan and the team at Smarter Alloys received $145,000 in grants from the Natural Sciences and Engineering Research Council of Canada and a consortium of universities involved in technology commercialization called the C4 Network. To qualify for this funding, Khan's process was closely vetted by two panels of business professionals. A patent application was also filed for his innovation.

The University of Waterloo helped initially by marketing the technology through its commercialization office, also known as WatCo, until Khan and his partners formed their own company Smarter Alloys.

The non-profit Ontario Centre of Excellence (www.oce-ontario.org) provided money from its Market Readiness Fund, which Khan says "propelled us out of the university and into the community."

Mars Discovery District (www.marsdd.com), a public-private partnership in Toronto, provided Khan's company with office space and an umbrella of support to connect them with potential partners, customers, investors and talent. And, at an event organized by Mars to help innovators connect with industry, Khan got his all-important introduction to Bombardier Aerospace, a prime backer.



GLENN LOWSON FOR TORONTO STAR

John Yeow, right, and Lawrence Wong are improving catheters to scan the body for diseases.

Helping detect cancer earlier

NANOTECH from **V1**

view scanning device, low power, etc. — allows us to access human cavities and characterize bio-samples that were not possible previously."

What makes these miniaturized catheters possible is the defining characteristic of a nanotube: its length is many millions times greater than its diameter, which gives it extraordinary strength and flexibility.

The catheter is likely to be a big step forward in the early detection of cancer and other diseases.

The challenge now, says Yeow, is two-fold.

First, he must find a way to "miniaturize a controllable mirror that is capable of large, angular scan angles."

Next, he'll work on "creating moving components on the order of the diameter of a human hair and integrating them within the catheter."

Yeow and his team have also been working on miniaturized x-ray devices that can be integrated into CT machines to provide high-quality images with lower radiation power.

He explains the value of miniaturization through nanotechnology is that "it allows us to improve the performance of existing devices."

Serendipity doesn't really play a big role in Yeow's work. He knows where he wants to get and the work consists of finding the way to do it.

Working closely with physicians, medical biophysicists and other users is critical, right from the start.

"We always have an end product in mind," he explains.

"We focus on developing technologies that will have a place in the market at the end of their development cycle."

Asked what the most important characteristics are for an engineer doing this kind of work, Yeow's first response is "creativity."

"And excellent hands-on capability," he adds.

He says engineering is vital to the practice of medicine, with most diagnostic and therapeutic advances made possible by engineers. "All medical instruments that exist today are a direct result of the creativity and imagination of people with engineering skills."

Tomorrow will bring new innovations, using nanotechnology, that Yeow couldn't have imagined when he was a student.

"When I was in engineering school, nanotechnology was a science in progress. Now, we are seeing more nanotechnology-engineered devices."

"Nanotechnology will have a huge impact on our daily lives in the future, be it more sophisticated medical instruments, more efficient power generators, more advanced communications systems, or more durable mechanical components."

WATERLOO LEADS WAY

The University of Waterloo offers the first MASc and PhD programs in nanotechnology of its kind in Canada.

The interdisciplinary research program, jointly offered by three departments in the faculty of science and four in the faculty of engineering, spans from basic research through to application.

One of the participating engineering departments is the Department of Systems Design Engineering (SYDE), the only one of its kind in Canada, with 26 full-time faculty members, 492 undergraduates and 113 graduate students.

For more information about SYDE, go to www.systems.uwaterloo.ca.

For information about nanotechnology, go to MRItechnicianschools.net/blog and scroll down to "25 ways nanotechnology is revolutionizing medicine."

App helps riders navigate on the GO

Smartphone software works as companion for commuters

SHARON OOSTHOEK
SPECIAL TO THE STAR

DAVID COOPER/TORONTO STAR

Hossein Rahnama and student Damyan Petkov, left, show Flybits's new Way Finder, which uses augmented reality to help people find their way.

Flybits is the odd name given to a made-in-Toronto smartphone app changing the way commuters here and in Paris navigate their surroundings as they go.

"It's about bits — zeros and ones — that fly. It represents wireless computing," says Hossein Rahnama, director of research at Ryerson University's digital media zone.

Flybits is also the name of the company Rahnama founded to build the app.

Flybits began life in 2004 as a research institute within the DMZ until Ryerson spun it off into a separate company with the help of MaRS, the Toronto-based innovation incubator.

Rahnama launched Flybits' first big-time app in 2010 as a pilot project for Paris Metro commuters whose mobility is constrained and for blind passengers or those with poor vision.

As commuters move about the system, the bilingual app locates elevators, transfer points and schedules for connecting trains.

Blind passengers can get information by shaking or tapping the phone to launch a text-to-speech function, and transit staff can use it to track passengers who may need help.

"It's important that the information you get on your phone is customized to your context: who you are, where you are, what you do," says Rahnama.

"Instead of searching for information, it will find you when you need it. We are building this intelligent network that can understand your intention and tries its best to give you relevant information."

Rahnama and his team of Ryerson co-op students have since used their Paris experience to build an app for GO Transit users.

Designed in partnership with Metrolinx, GO Mobile provides information, such as the nearest station, tailored to a commuter's location. It also gives real-time departures from Union Station.

Passengers with special needs have access to the same type of functions available in the Paris Metro. While they work best on an Android phone, they can also be used on an iPhone.

GO Mobile will even alert napping commuters to wake up as they approach their station.

"We saw (the app) as a great opportunity to give our customers GO service information when they need it, wherever they need it," says Metrolinx spokesperson Malon Edwards.

So far, 93,000 of 217,000 daily GO Train passengers have downloaded the app since its launch in November.

"When I'm out with friends and they want to know how long they can stay out, I whip out my app and find out when their buses are leaving," says Jaspaul Bola, a third-year Ryerson computer science student who helped develop the app. "Otherwise, it's hard to convince them to stay out longer."

Bola knows the way he uses GO Mobile may not be representative of all commuters' needs. So he is combing through responses from the app's feedback function to see how it might be tweaked.

Rahnama says he would eventually like to design an app for the TTC, but the lack of wireless Internet in the tunnels makes that out of the question for now.

Meanwhile, Flybits is testing a version of its app at the airport.

"When you walk into Pearson, we'll know your frequent-flyer number and your itinerary and can navigate you to the check-in gate," says Rahnam. "And, if there's a cancellation, we can provision you with a hotel coupon on your handset."

Pearson's pilot app even has a function to help you find your car in the airport's mammoth parking garage. Before leaving your car, take a picture with your smartphone of a code printed on the garage floor, or bookmark your location. The app will then guide you back.

While the airport project is still being tested and has no firm launch date, it and other Flybit apps conform to government privacy standards, says Rahnam.

That means any data users feed into their app is encrypted. And once they get back the information they need, that data is removed from the Flybit server.

All of which means Flybits does not profile its users and is not set up for personalized ads.

"We don't want to do that (ads) now," says Rahnama.

"The whole purpose is to give useful info."

Robot doesn't nag, he motivates

ROBOTS from V1

"People are living longer, so this is one way we may be able to improve their quality of life and keep them independent."

Not that Brian will fetch and carry, do the housework and feed the cat.

Although he can speak, change his expression, move his head and arms, he's not mobile.

Nejat, an assistant professor in the Faculty of Applied Science and Engineering, explains his intended role:

"We focused on specific activities the robot can engage a person in, at the same time providing social stimulation.

"It can play memory games and card games to keep the brain active. It can prompt someone through the steps of brushing their teeth, such as putting the toothpaste on the brush, or of eating a meal, or it can remind them of a doctor's appointment.

"No, it doesn't nag! It motivates."

The robot's sensors watch, listen and remember. It will treat different people in different ways, depending on the understanding it develops of them.

"It's like we're sitting here and reading each other's body language and expressions as we talk," says Nejat. "Are we open, are we closed? Making eye contact or looking away? Are we happy? Are we sad? Stressed? It can pick up those cues and react."

BILL TAYLOR FOR TORONTO STAR

Robot Brian can help the elderly through social stimulation, such as memory games, or by reminding them of tasks such as taking pills or eating dinner.

Brian's synthesized speech is more human than HAL, the robot in *2001: A Space Odyssey*, ironic, given that HAL was voiced by flesh-and-blood Canadian actor Douglas Rains.

He's almost 5 feet tall, weighs about 150 pounds and when he moves, it's not soundless. That's deliberate, Nejat says, to give the sense that Brian, like everyone else, has his personal space.

According to the Public Healthy Agency of Canada, the proportion of seniors in the population rose from one in 20 in 1921 to one in seven in 2009. By 2041, it'll be almost one in four.

Robots could take over repetitive routine tasks that are part of a caregiver's duties, and, says Nejat, "can overwhelm them. We have to remember, too, that many caregivers are themselves a part of the aging baby boomer population."

Baycrest hospital, nursing home, assisted-living facility and research centre is involved with testing the robot "almost as a social coach," says Bianca Stern, the centre's director of culture, arts and innovation.

"As clients become more impaired and require assistance with daily living activies, a robot can potentially be used to give verbal cues and social encouragement."

Among the robot's potential functions could be working in a group with a therapeutic therapist present, or perhaps, at mealtimes, reminding residents "who are potentially more distractible" to keep eating, she says.

Work on Brian has been going on for six years and Nejat figures it could be another decade before a whole generation could be at work across North America.

Stern believes that could happen even quicker, because "robotics is a field that has expanded significantly, especially in Asian countries."

Nejat says the robot's records of individual histories should help doctors track any improvement in a patient's cognitive abilities, giving it a role alongside medication and other therapy in delaying the onset and progress of dementia.

Cost, she says, should not be a major factor. "Brian's platform cost about $3,000 to build. Total? Probably less than five grand. It won't just be a novelty that people can't afford."

Something that OHIP might pay for? She laughs.

"Good question. We should talk to the government. If it's being used as therapy for cognitive impairment, then there could be a good case."