



**DATA  
ANALYTICS &  
ARTIFICIAL  
INTELLIGENCE**



UNIVERSITY OF  
**TORONTO**

**Engineering**

# DATA ANALYTICS & ARTIFICIAL INTELLIGENCE RESEARCH AT U of T ENGINEERING

Data is everywhere. From point-of-sale information collected by retailers to traffic sensors, satellite imagery and the tidal wave of social media posts, we produce billions of gigabytes worth of information each day.

U of T Engineering researchers are drawing critical insight and information from mass data by marrying emerging techniques in big data, deep learning, neural networks and artificial intelligence (AI) to design smarter systems. We are creating algorithms that crawl through the genome to understand how specific mutations result in diseases such as autism, cancer and cystic fibrosis, and suggest possible treatments. We are teaching computers to recognize speech and images, including individual human faces, with applications in sectors from security to aesthetics. We are also building computer models that optimize surgical schedules, making better use of valuable resources.

Society is in the midst of what is being called the Fourth Industrial Revolution. Data analytics and AI have tipped the balance, fundamentally changing the way we do business, treat disease, interact with technology and communicate with each other. Our expertise in these areas will help to reshape processes to improve lives and generate value for people around the world.

## SELECTED AREAS OF EXPERTISE IN DATA ANALYTICS & AI RESEARCH AT U of T ENGINEERING

- » Artificial Intelligence
- » Augmented Reality
- » Autonomous Vehicles
- » Bioinformatics
- » Communications
- » Computing Systems (from Internet of Things to hardware and software)
- » Computer Architecture
- » Computational Medicine
- » Cybersecurity
- » Data Mining
- » Fintech
- » Intelligent Robotic Systems
- » Intelligent Transportation
- » Machine Learning
- » Neural Networks
- » Smart City Platforms

## SELECTED EDUCATIONAL OFFERINGS IN DATA ANALYTICS & AI

Our Master of Engineering students can choose from a wide range of technical emphases, including Robotics & Mechatronics and Analytics. Within the Engineering Science program, undergraduates can major in Robotics or Machine Intelligence — the first program of its kind in Canada to specialize in the study, development and application of algorithms that help systems learn from data. Undergraduates in our core engineering disciplines can pursue complementary studies in Robotics & Mechatronics through multidisciplinary minors.

## RESEARCH CENTRES & INSTITUTES

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- 2017** **VECTOR INSTITUTE**

Building on the existing expertise of the globally renowned deep learning team at U of T, the Vector Institute is driving excellence and leadership in AI to generate talent, foster economic growth and improves lives. The Institute is funded by the governments of Ontario and Canada, and collaborates with 30 industrial partners, including Google, Uber, Shopify and several financial service institutions.
  - 2017** **COMPUTER HARDWARE FOR EMERGING SENSORY APPLICATIONS (COHESA)**

This NSERC Strategic Partnership Network brings together researchers from academia and industry to design computer hardware optimized for applications in machine learning and artificial intelligence. Industrial partners include chip manufacturers AMD and Intel as well as technology firms such as Google, IBM and Microsoft.
  - 2012** **SOUTHERN ONTARIO SMART COMPUTING INNOVATION PLATFORM (SOSCIP)**

SOSCIP is a research and development consortium that pairs academic and industry researchers with advanced computing tools to fuel Canadian innovation within the areas of agile computing, cities, mining, health, digital media, energy, cybersecurity, water and advanced manufacturing.
  - 2011** **SMART APPLICATIONS ON VIRTUAL INFRASTRUCTURE (SAVI)**

This NSERC Strategic Partnership Network built a next-generation internet platform that investigates cloud computing, software-defined networking and Internet of Things. One use case is Connected Vehicles and Smart Transportation, which integrates data from a wide variety of sensors — highway cameras, road incident alerts, transit systems, border crossings — to help ease congestion, improve personal safety, increase energy efficiency and reduce waste in smart cities.
  - 1991** **CENTRE FOR MANAGEMENT OF TECHNOLOGY AND ENTREPRENEURSHIP (CMTE)**

CMTE creates innovative solutions within the Canadian financial services industry in three main areas: financial modelling, data mining and analytics, and machine learning. This multidisciplinary centre also provides engineering students with industry-focused learning opportunities to further develop talent in these areas.



## RESEARCH IMPACT

“Humans and machines think differently, and they excel at different tasks. Our job as software and hardware engineers is to design machines and algorithms that perform their tasks faster and more efficiently, which frees up human capital to focus on creativity and innovation.”

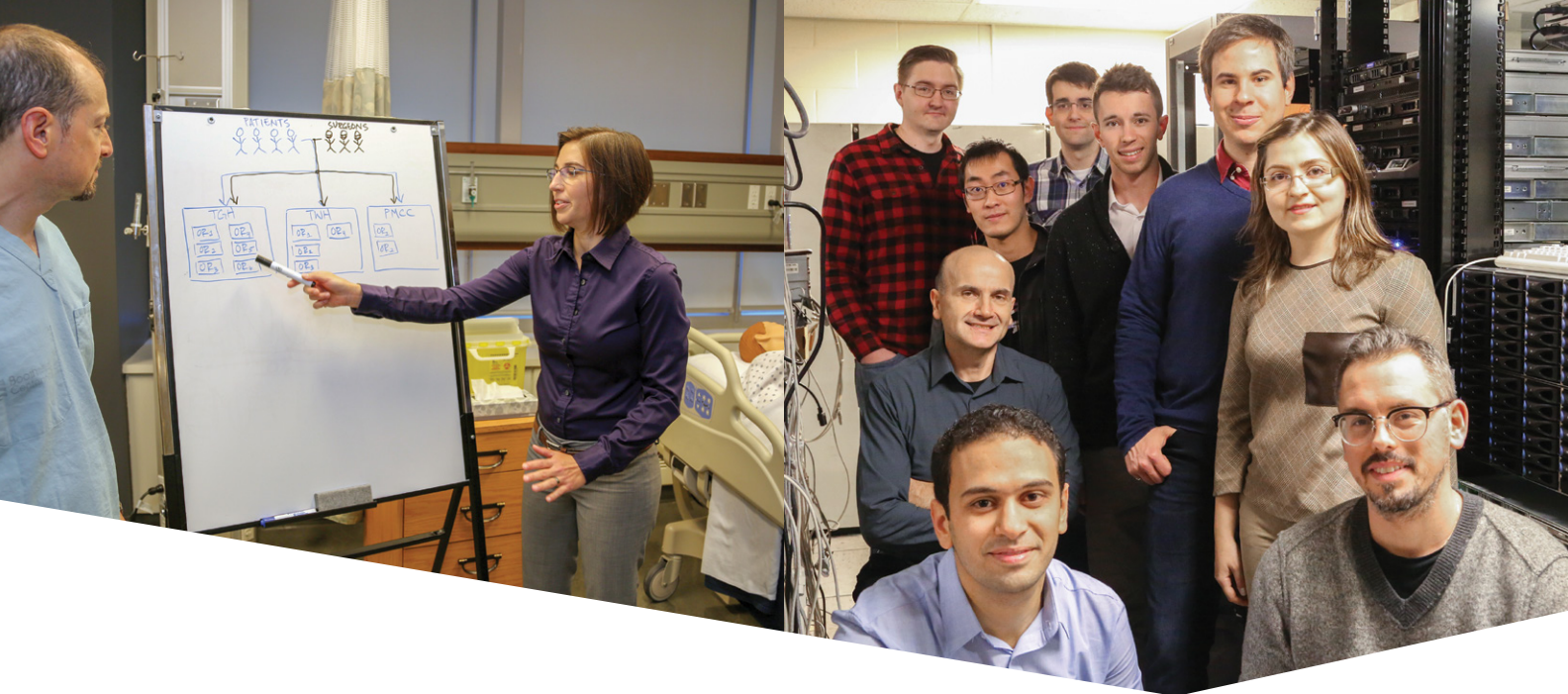
**PROFESSOR NATALIE ENRIGHT JERGER**  
Percy Edward Hart Professor of Electrical  
and Computer Engineering

## FROM LIP READING TO LIP GLOSS

Ten years ago, computer engineering professor **PARHAM AARABI** was trying to teach computers to read lips. His theory was that it would improve the ability of computers to respond to voice commands, or listen in on conversations between suspected criminals. However, the technology turned out to have another useful application in a completely different field — the cosmetics industry.

In 2007, Aarabi created the spinoff company ModiFace to build advanced facial visualization software. Companies such as Sephora, L’Oreal, Allergan, Vichy and Clairol use technology developed by ModiFace to provide customers with real-time previews of how a given product will look.

In 2018, ModiFace was acquired by L’Oréal, making it the first technology company to be purchased by the French cosmetics giant. Aarabi remains its CEO, and the company is headquartered in Toronto. Each year, ModiFace hires 50 undergraduates through U of T Engineering’s Professional Experience Year Co-op program, and most of its employees have a U of T connection.



## OPTIMIZATION FOR SMARTER HEALTH CARE

Long waitlists for elective surgeries are a challenge in the Canadian health-care system. According to industrial engineering professor **DIONNE ALEMAN** (right), the problem may not necessarily be a lack of resources, but rather a result of not using the resources we have as efficiently as we could.

As a member of the Centre for Healthcare Engineering at U of T, Aleman collaborates with medical professionals such as Dr. David Urbach (left), a surgeon and senior scientist at the Toronto General Research Institute, on a variety of issues in the delivery of health care. Using data from Toronto General Hospital, Toronto Western Hospital and the Princess Margaret Cancer Centre, Aleman and her team have built a mathematical model that can optimize the matches between patients, surgeons and operating rooms to generate the most efficient schedule.

One technique the team uses involves pooling resources. Rather than each hospital maintaining its own waiting list, patients would be treated as a single large waiting list, and assigned to a given surgeon or operating room to minimize the time when resources are unused. Using this approach, Aleman and her team have shown that they can increase the number of patients treated in a given time period by up to 30 per cent.

## HARDWARE ACCELERATION FOR DEEP LEARNING

Since the 1970s, the number of components that can be fit into an integrated circuit has doubled roughly every two years, a phenomenon known as Moore's Law. Faster processors have fuelled the rise of machine learning and artificial intelligence, but as these applications become more widespread, the need for speed will only continue to grow.

Professor **ANDREAS MOSHOVOS** (middle row, left) in The Edward S. Rogers Sr. Department of Electrical & Computer Engineering and his team design computer chips that are optimized for machine learning applications. Just as graphics accelerator chips improve video displays by completing many common operations in parallel, chips optimized to execute machine learning calculations can offer speeds anywhere from 10 to 1,000 times faster than general-purpose processors.

Moshovos heads NSERC COHESA (Computer Hardware for Emerging Sensory Applications), a national network of researchers from academia and industry that are finding ways to eliminate needless or repetitive operations and create chips ideally suited to artificial intelligence. In the future, such chips could power smarter voice-activated assistants, video recognition software or self-driving vehicles.



# THE FUTURE OF DATA ANALYTICS & AI RESEARCH

## A GLOBAL HUB FOR AI

Artificial intelligence has deep roots at the University of Toronto: computer science professor Geoffrey Hinton is widely recognized as the pioneer of deep learning, one of the most powerful approaches to the field. Today, Hinton is the Chief Scientific Advisor to the Vector Institute, a vibrant community of innovative problem-solvers, working across disciplines on both curiosity-driven and applied research. The organization also includes Professor Brendan Frey, one of Hinton's former students.

Founded in 2017, the Vector Institute aims to strengthen Toronto's global leadership in machine learning and artificial intelligence. It will also educate and prepare thousands of graduate students to fill booming demand for experts in these emerging fields.

## IMPROVING NETWORK AGILITY THROUGH SOFTWARIZATION AND INTELLIGENCE

In Canada, the major internet service providers began as telecommunications companies. As they shifted from providing telephone or cable television service to providing internet connectivity, they built large and complex networks of physical hardware, from routers to switches, increasing their maintenance costs.

Electrical and computer engineering professor **ALBERTO LEON-GARCIA**, UofT Distinguished Professor in Application Platforms and Smart Infrastructure, is leading a team of researchers who will focus on replacing purpose-built hardware with flexible software that accomplishes the same tasks. This 'softwarization' of network infrastructure, combined with intelligence garnered from analytics and learning, greatly reduces the costs of both maintaining and updating the system. It also makes it easier to adapt the network to new devices, such as those in the Internet of Things.

Funded by a Collaborative Research and Training Experience (CREATE) grant from NSERC, Leon-Garcia's program in Network Softwarization includes partners at three other Canadian universities as well as companies such as TELUS, Bell Canada and Ericsson. Through courses and a series of internships, the program will prepare a new generation of engineers to build more agile, adaptable networks that are both more functional and less expensive for consumers.

## MINING GENOMIC DATA

The Human Genome Project began in 1990 and took more than a decade and billions of dollars to complete. Today, a genome can be sequenced in an afternoon, for a few hundred dollars. The key challenges of genomics lie not in generating the data, but in transforming that data into useful knowledge.

Deep Genomics, founded in 2015 by electrical and computer engineering professor **BRENDAN FREY**, Canada Research Chair in Information Processing and Machine Learning, is on a mission to predict the consequences of genomic changes by developing new deep learning technologies. The company grew out of Frey's research on deep learning, a form of artificial intelligence that has already revolutionized web search, voice recognition and other areas. By applying these techniques to gene sequence data, Frey and his team aim to not only understand how mutations lead to diseases such as cancer, cystic fibrosis and autism, but also point the way toward drugs or other interventions that could better treat these conditions.

Deep Genomics has raised more than \$20 million in funding and is doubling its staff from 20 to 40 employees.



## UNIVERSITY OF TORONTO FACULTY OF APPLIED SCIENCE & ENGINEERING

### LEADING INNOVATION STARTS HERE

Connect with us to discuss how a partnership with UofT Engineering can benefit your organization:

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#### STATEMENT OF ACKNOWLEDGEMENT OF TRADITIONAL LAND

We wish to acknowledge this land on which the University of Toronto operates. For thousands of years it has been the traditional land of the Huron-Wendat, the Seneca, and most recently, the Mississaugas of the Credit River. Today, this meeting place is still the home to many Indigenous people and we are grateful to have the opportunity to work on this land.