Why Canada is Becoming a Hub for A.I. Research

Thu, 07/13/2017 - 3:21pm   Comments   by **Ryan Bushey** **- Digital Editor -**   **@R_Bushey**

Artificial intelligence (A.I.) could become a game-changer for multiple industries.

Powerful algorithms may soon be able to quickly sift through reams of data and information, delivering quantifiable insights for tasks such as enhancing guidance systems for self-driving cars, assisting physicians in diagnosing patients, or helping farmers implement plans that simplify the management and protection of their crops.

Technology giants in the U.S. like IBM and Microsoft are exploring business opportunities where A.I. could have the most impact, but an ecosystem for this type of R&D is already thriving in Canada.

Our neighbor to the north has produced several pioneers in A.I.

Prominent computer scientists like Geoffrey Hinton, Ph.D., and Yoshua Bengio, Ph.D., started their careers in Toronto laying the groundwork for various A.I. oriented fields.

Hinton, an engineering fellow at Google and professor emeritus of computer science at the University of Toronto, is considered a pioneer in training neural networks with multiple layers, a computing technique that provides A.I. with greater recognition capabilities.

Searching for a picture on Google as well as dictating text on your smartphone via voice recognition are advancements made possible in part on technology derived from Hinton's ideas.

Bengio, a graduate of McGill University, is another noted expert in deep learning coming out of Canada. He is the head of the Montreal Institute for Learning Algorithms and recently signed on as an adviser to Microsoft on its artificial intelligence efforts.

In addition to Canada's history of producing some of the most well-known experts in A.I. research, the government— under Prime Minister Justin Trudeau—has a desire to capitalize on these breakthroughs as much as possible. To do this, they have launched a comprehensive initiative designed to help the A.I. industry flourish within the country.

The Vector Institute, an independent not-for-profit institution based in Ontario, was created as a response to this initiative.

The organization receives an estimated $150 million investment from both the Canadian government and as well as Canadian businesses.

Lead by research director Richard Zemel, a professor of computer science at the University of Toronto and Senior Fellow at the Canadian Institute for Advanced Research, the Vector Institute focuses on building and sustaining AI-based innovation, growth, and productivity in Canada.

In an interview with *R&D Magazine,* Zemel discussed the specific strategy the Vector Institute will implement to take advantage of these opportunities as well as where he sees the industry moving going forward.

R&D Magazine: **Describe what role the Vector Institute will play in this burgeoning field?**

Richard Zemel: "The launch of the Vector Institute in March this year was a response to a significant opportunity to make Canada a global leader in artificial intelligence. We know that Canada produces some of the best and brightest graduates in machine learning and deep learning, from cities like Toronto, Montreal, and Edmonton. We also know that we need to increase awareness among companies in Canada, both large and small, of the transformative potential of artificial intelligence. So that's why we're here –to drive excellence and leadership in Canada's knowledge, creation, and use of artificial intelligence to foster economic growth and improve the lives of Canadians.

The Vector Institute will lead Ontario's efforts to build and sustain AI-based innovation, growth and productivity in Canada by focusing on the transformative potential of deep learning and machine learning. It will do so by working with Canadian industry and public institutions to ensure that they have the people, skills and resources to be best in class users of artificial intelligence. The Vector Institute will also support Canada's innovation clusters and help start-ups grow to become Canadian-based global leaders. An essential component of Vector's mission is to attract global talent focused on research excellence; our researchers and academic partners will be part of a vibrant community of innovative problem-solvers, working across disciplines on both curiosity-driven and applied research."

R&D Magazine: **What elements are making Canada become a hub for artificial intelligence research?**

Richard Zemel: "Canada is home to some of the brightest minds in the field of artificial intelligence; it has been at the academic forefront of the broad field of AI for over 30 years. Specifically in the areas of machine learning, reinforcement learning and deep learning, leading researchers and professors have been graduating some of the most promising talent out of cities like Toronto, Montreal and Edmonton.

Canada is fast becoming a global hub for artificial intelligence research as support and interest grow among academic institutions, private companies, and governments.

The number and variety of companies that have signed on as sponsors of the Vector Institute is an indication that industry understands the transformative potential of AI.We also have a large number of start-up companies – and several business incubators – with an interest in developing, applying and commercializing AI technology.Recent announcements from Uber, Google Brain, and DeepMind to expand their research capacity in Canada are further evidence that Canada is emerging as the place to do AI research, and also to apply it.

And what we hear from many students, researchers and scientists is that they want to live in Canada – our diversity, public healthcare, education system and quality of life are all very appealing.We are tremendously excited to work with industry, start-ups and institutions to

build and sustain Canada's AI ecosystem."

R&D Magazine: How is Canada's research environment for A.I. different from the U.S.? Are there specific resources available for scientists in the country that are not available in the U.S.?

Richard Zemel: "As the Research Director for the Vector Institute, my first priority is to build out the team of faculty and research scientists who will be the drivers of research and advanced education in deep learning and machine learning at the Vector Institute. We have a very deep talent pool of deep learning and machine learning expertise here in Toronto, and our goal is to build on and expand that both in academia and in industry. Canada has a strong tradition of curiosity-driven research, and in the fields of machine learning and deep learning in particular NSERC and CIFAR have been strong contributors to the research developments. A key aim at Vector is to continue and build on this fertile research environment.

We've had very positive conversations with many individuals currently based in leading institutions and labs around the world, and there is a lot of excitement and interest in Vector, and in the growing Canadian ecosystem. I'm excited to say that we're getting ready to make multiple announcements on hiring top talent for Vector in the coming months.

In creating the Vector Institute, it has been very important to me and the team to build flexibility into our operating model. The advantage of Vector being an independent, not-for-profit institution means that our researchers won't necessarily be faced with having to decide between working in academia or working with industry.Vector researchers will be able to work on projects with the private sector – so long as their research and academic obligations are fulfilled. This flexibility, combined with growing the pool of top talent, lends itself to one of the Vector Institute's core objectives, which is to enable companies in Canada to become best-in-class adopters of AI technology.

It will make Vector, Toronto and Canada a place where top talent and industry converge to create a vibrant and lasting ecosystem.

The Vector Institute is a response to a challenge and an opportunity. It's well-known that Canada – with cities like Toronto, Montreal and Edmonton – produces world-class talent trained in machine learning. The University of Toronto's students have gone on to lead and work in AI labs at Google DeepMind, OpenAI, Apple, Facebook and Microsoft.

The challenge we face in Canada is that while our graduates are in high demand, there isn't the ecosystem here in Canada that we would want to see around such talent, and Canadian firms lag behind their international counterparts in investments in innovation and research.

But with the launch of the Vector Institute, I think we're at a turning point. Since Vector's launch, Uber has announced that it will open a new branch of its Advanced Technologies Group, lead by Raquel Urtasun. Meanwhile, Google announced the launch of Google Brain Toronto and DeepMind announced the opening of its first ever international AI research office in Edmonton.

And I've heard from my own students and postdocs that they are deciding to stay in Canada because of the emerging AI ecosystem; while in the recent past these opportunities did not exist, they are very excited about the prospect of staying here to continue doing research and working with companies. And while travelling to conferences and summer schools recently I've heard a lot of interest from students elsewhere as well.

Many of these individuals want to live in Canada – our diversity, public healthcare, education system and quality of life are all very appealing. And as we create meaningful opportunities for them to pursue careers here, they will either stay or come from abroad. And that's what we plan to do."

R&D Magazine: Please elaborate on specific fields of A.I. research that could yield the most promising results and why (i.e. computer vision, neural networks etc)

Richard Zemel: "Many of the current successes have been in areas such as machine vision (automated driving), language (automated speech recognition in voice assistants, machine translation), and recommender systems. Other areas that are ripe for advances include healthcare and robotics. All of these areas have a wealth of data, which makes them amenable to machine learning methods. Other areas where we may see progress in the near future include automated drug and manufacturing design, and education. Progress in each of these cases has been and will be fueled by research advances, in learning algorithms, optimization, and hardware."

R&D Magazine: Please discuss specific industries that could benefit from the research that emerges from the organization. Also, are there any promising startups/companies in Canada working on novel projects?

Richard Zemel: "It is early days for the Vector Institute, and at this stage it's difficult to know exactly how Vector's research will affect different sectors. Our first step towards our goal to drive research excellence is to recruit the faculty and research scientists who will undertake both curiosity-driven and applied research with Vector. That process is underway now.

The list of companies that are sponsoring the Vector Institute (see the full list here: http://vectorinstitute.ai/#partners) can give us a sense of where we can expect AI advancements to have an impact. More than 30 companies have committed a combined total of over $85 million over ten years to support the Vector Institute, representing sectors as diverse as finance, insurance, education, retail, advanced manufacturing, construction and transportation, reflecting the transformational potential of deep learning and machine learning in Canada.

Vector's sponsors include several start-up and scale-up companies and we have also established an advisory committee to collaborate and create opportunities within the Institute for all start-up and scale-up firms."

R&D Magazine: The Vector Institute is based in Toronto, but companies like Google Deepmind are opening a new research lab in Alberta. Will each institution work together with each other or will each province have their own specialized network of research?

Richard Zemel: "Yes. Vector will collaborate with other organizations that make up the pan-Canadian AI ecosystem, including academic institutions, incubators, accelerators, start-ups, scale-ups and established companies. We believe the recent DeepMind announcement, and others like it, are good for the Canadian AI ecosystem as a whole.

There are currently some areas in which different research groups have notable strength, such as reinforcement learning in Alberta, dialogue systems in Montreal, and statistical models in Toronto. But these strengths overlap considerably, and the field is rapidly evolving, so I expect a lot of cross-fertilization and synergies to emerge.
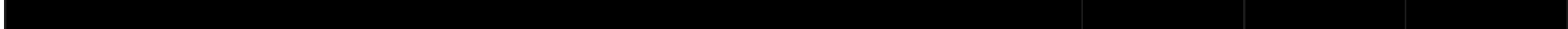
Collaborating with other jurisdictions and organizations in Canada's AI ecosystem will help Vector achieve its vision to drive excellence and leadership in Canada's knowledge, creation and use of artificial intelligence to foster economic growth and improve the lives of Canadians."

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How Toyota's New Venture Fund Will Tackle A.I. Investments

Thu, 07/20/2017 - 10:17am   by **Ryan Bushey** **- Digital Editor -**   **@R_Bushey**

Breakthroughs in robotics and artificial intelligence are poised to revolutionize a diverse array of industries.

Japanese carmaker Toyota hopes to be at the forefront of these innovations, which is why they've launched a new venture capital fund.

Toyota A.I. Ventures, a new subsidiary of the Toyota Research Institute (TRI), will use an initial fund of $100 million to collaborate with entrepreneurs from all over the world, in an effort to improve the quality of human life through artificial intelligence.

"The fund came together roughly over the last year or so with the thinking being there's a tremendous amount of innovation happening around the world in startup companies. We wanted to tap into that cauldron of innovation that's bubbling out there," explained Jim Adler, the managing director of the venture fund, to *R&D Magazine* in an interview.

Toyota A.I. Ventures focus is "not research funding," said Adler. Instead, the venture will work with these companies at an early stage and offer a "founder-friendly" environment that won't impact the startup's ability to work with other investors. They will also offer assistance with technology and product expertise to validate that the product being built is for the right market, and give these entrepreneurs access to Toyota's global network of affiliates and partners to ensure a successful market launch.

Adler's team will specifically look at the startups focusing on autonomous mobility, robotics, data analytics, and cloud computing.

Three startups specializing in these fields were already part of the venture capital organization when it launched:

- Intuition Robotics: A company based in Israel that is creating companion robots for the elderly. Their first product is called ELLIQ, which helps senior citizens use a number of technologies, like video chats, online games, and social media, to stay in touch with family and friends so they don't feel overwhelmed by new technology.
- SLAMCore: a venture working on visual tracking and mapping algorithms for AR/VR systems, mobile robotics, and autonomous vehicles.
- Nauto: a firm developing hardware for vehicles infused with an artificial intelligence platform that can make any car a smart car.

These three companies are trying to tackle some of the less well-defined areas artificial intelligence could help with. This product suite can help senior citizens become more accustomed to operating in a new digital ecosystem, SLAMCore's software can help robots and other vessels quickly scan and become adjusted to new environments, and Nauto's hardware can enhance safety levels when driving.

Opportunities for A.I.

"One of the areas I think is fascinating for A.I. is understanding how certain actors on the road are socially interacting. It's not just cars of course, but a mix of the obstacles that get in the way," he said.

There's an additional level of complexity when focusing on the impact of different local customs and social contracts in place in different regions. For downtown San Francisco, for example, pedestrians pretty much rule the road whereas its taxicabs in New York City.

"How will an autonomous vehicle grasp what safe driving looks like? It's not just the rules of the road because sometimes if you follow the rules of the road exactly you can become less safe," said Adler.

The best way to accomplish this goal is to perform "regression tests" to create systems that, not only understand dangerous situations related to driving behavior, but also ensure these novel systems are in fact safe themselves, explained Adler. This concept would mean each iteration of the system is an improvement over the last one.

"We've tested cars for decades, but data is critical for understanding these unpredictable situations and doing constant quality control," he added.

Strategies for new breakthroughs

Artificial intelligence is still a burgeoning field, but a crop of startups are attempting to make their own groundbreaking algorithms and well established companies are making forays into the field too.

Both startups and established companies like Toyota are equipped to tackle research challenges associated with A.I., but in different ways, said Adler.

"There are advantages to be garnered from both speed and scale. Startups are great at running multiple experiments with an incredible ability to test things out," Adler said.

"We must connect to that ecosystem of innovation because funds like ours are looking to be fast and connected to that speed within the industry."

Artificial intelligence technology will advance regardless of intervention; there is really no stopping it, said Adler. The key will be advancing it in a way that will most benefit society.

"It's so important that the wisdom keeps up with the technology so it could fortify humanity in positive ways. It's great to have these

discussions earlier rather than later," he concluded.

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Startup Uses A.I. to Streamline Drug Discovery Process

Fri, 07/21/2017 - 11:52am   by **Ryan Bushey** **- Digital Editor -**   **@R_Bushey**

The drug discovery and development process could use an upgrade.

Pharmaceutical firms spend years sinking a tremendous amount of resources into developing drugs that could treat devastating diseases like cancer and Alzheimer's. Factors like successful reactions in animal models, efficient clinical trial recruitment, and promising results in the first segment of human experiments deliver promising data that helps companies advance their drug candidates through this process.

However, all it takes is one issue such as an unexpected safety concern to quash a program that took multiple years to put together.

This is where startups offering artificial intelligence (A.I.) algorithms could play a beneficial role.

One firm, Exscientia, is using its A.I. fueled programs in conjunction with experienced drug developers to implement a rapid 'design-make-test' cycle. This essentially ascertains how certain molecules will behave and then predicts how likely they are to become useful drugs.

The Dundee, Scotland-based biotech has signed a number of partnerships with major drug companies, including Sanofi and Evotec. It recently signed a deal with GlaxoSmithKline worth an estimated $43 million to help discover unique selective small molecules for up to 10 disease-related targets.

In an interview with *R&D Magazine,* Andrew Hopkins, Exscientia's CEO, discussed how his company's platform works and the potential impact A.I. can have on the pharmaceutical industry.

R&D Magazine: Describe what your company does. How does your platform work? What makes your approach unique compared to other firms working in this space?

Hopkins: "We consider Exscientia to be at the forefront of Artificial Intelligence (A.I.)-driven drug discovery and design. Our approach is to fuse the power of A.I. with the discovery experience of seasoned drug hunters, and we believe we are the first company to automate drug design, surpassing conventional approaches. Our innovative platform enables breakthrough productivity gains as well as new approaches to improve drug efficacy.

Novel compounds prioritized for synthesis by Exscientia's A.I. systems simultaneously balance potency, selectivity and pharmacokinetic criteria in order to deliver successful experimental outcomes. By applying a rapid 'design-make-test' cycle, the Exscientia A.I. system actively learns from the preceding experimental results and rapidly evolves compounds towards the desired candidate criteria.

Exscientia first developed its platform to design efficacious, selective single-target compounds, whilst further innovation now allows the same platform to design small molecules with dual pharmacology ('bispecifics'), as well as more complex target product profiles guided by high content phenotypic data.

Exscientia is now collaborating with several leading pharmaceutical companies, including Evotec (immuno-oncology), Sanofi (metabolic disease), Sumitomo Dainippon Pharma and Sunovion Pharmaceuticals (CNS) and GSK (multiple targets)."

R&D Magazine: Can you discuss the partnerships you've struck with pharmaceutical companies like GlaxoSmithKline and Sanofi? What treatment areas are you targeting? What role do you see your firm playing in this development process?

Hopkins: "In early May we announced a strategic research collaboration and license option agreement with Sanofi in the area of metabolic disease. As part of this agreement, Exscientia will be responsible for all compound design, whilst chemistry synthesis will be delivered by Sanofi. Delivery of new therapies for metabolic disease (such as diabetes) is hampered by a paucity of single targets that are amenable to drug discovery. To address this challenge, Exscientia will apply its platform to identify and validate combinations of drug targets that could work synergistically and be amenable to Exscientia's bispecific-small-molecule design strategy – where a small molecule is designed to be compatible with two distinct drug targets.

In July this year we entered into a strategic drug discovery collaboration with GlaxoSmithKline (GSK). During this collaboration, Exscientia will apply its A.I. enabled platform and combine this with the expertise of GSK, in order to discover novel and selective small molecules for up to 10 disease-related targets, nominated by GSK across multiple therapeutic areas.

Applying our approach to client discovery projects has already delivered candidate-quality molecules in roughly one-quarter of the time, and at one-quarter of the cost of traditional approaches. Our intention therefore is to apply these capabilities to projects selected by GSK."

R&D Magazine: What are the benefits of performing this analysis with artificial intelligence in an outside capacity versus having these drug giants do it in-house?

Hopkins: "A lot of big pharma companies are exploring the use of A.I. now, as evidenced by our own experience and deals. But they don't have the A.I. skills in house. As tends to happen, big pharma companies are not innovators and so they look outside for new technologies. They do have targets and expertise in preclinical and clinical development though and so that, in combination with our own proprietary algorithms and capabilities, is where the real synergies happen.

At Exscientia, human drug discovery experts have worked alongside the A.I. approaches for many years. The highest profile among these is Andy Bell, a co-inventor of sildenafil (Viagra) and key contributor to many other successful projects during his previous work at Pfizer, in particular as the anti-fungal compound voriconazole (Vfend). Having the opportunity to meld this knowledge with A.I. techniques over a number of years to develop an integrated system is beyond the timelines that large pharmaceutical companies can typically sustain these days."

R&D Magazine: What are the benefits of using artificial intelligence in the drug discovery and development process? Are

there certain areas where this technology could be more effective?

Hopkins: "A.I. is a new approach to drug discovery. We have designed dedicated A.I. algorithms that form part of a highly integrated 'design-make-test' cycle for rapidly generating high quality drug candidates. As part of this process, the A.I. algorithms deliver the new designs, which are then rapidly synthesized and tested in small batch. The system is uniquely able to learn from both existing data resources and the enhanced data coming in from the cycle. The principle is not dissimilar to how a human would learn, but the A.I. process is far more effective at identifying and assimilating multiple subtle and complex trends. As a result, the A.I. driven process is more likely to achieve the end goal and to do this more rapidly and efficiently than traditional human endeavor.

One of the key opportunities is that the amount of data now available is so vast yet, beyond a human's individual capability. For A.I. focused towards drug design, where Exscientia concentrates its expertise, the typical sources of information would be vast databases of chemical structure, pharmacology, bioassays data as well as other supporting literature and patent information.

Working from a blank sheet of paper, the A.I. algorithms apply the distillation to the design of new, original small molecules. Successful molecules will hit the desired target whilst at the same time avoiding known selectivity, toxicology or pharmokinetic issues (among many other parameters). Further refinement through the integrated design-make-test cycle leads to completely new and optimized molecules (and IP) for advancing towards the clinic.

A.I. is also being applied to many areas of drug and clinical development. For example A.I. approaches might look at better patient stratification for clinical trials, thereby fitting the patient to the treatment being tested better, enabling quicker recruitment and increasing the likelihood of getting the required clinical response for regulatory approval. Provided there are general trends existing within the data of interest, A.I. algorithms should be able to harness these into a predictive method that can compete with more traditional human tactics."

R&D Magazine: Please elaborate on other applications for artificial intelligence in pharmaceuticals. What are some other advantages and/or drawbacks these systems could have when it comes to creating the next potent drug or helping with R&D productivity?

Hopkins: "The need to reduce R&D costs is a major driver. Lead optimization is the highest cost per launched drug due to the number of projects researched that never reach the market. Improving discovery efficiency through high quality candidates that are discovered effectively would dramatically improve these metrics. The Exscientia approaches have already demonstrated significant improvements in productivity with one collaborative project (Sumitomo Dainippon) having achieved its key endpoints in just one quarter of the typical effort (in both time and compounds synthesized).

The need to reduce healthcare costs overall will also be a driver to consider the application of A.I. techniques. Provided the challenge given to the A.I. algorithm is reasonable and achievable, it should be able to benefit the overall drug discovery process. Where things might not meet expectation is where there are insufficient data or insufficient trends within the data for any approach to make progress. For that reason we are very careful at Exscientia to qualify the opportunity.

One area of interest is see whether A.I. approaches can be used to design drugs that could modulate multiple biological processes within a single molecule (e.g blocking tumor signaling and survival mechanisms, boosting immune response). These could be powerful additions to the therapeutic arsenal. Exscientia is looking to tackle efficacy directly by designing a breed of small molecules that we call bispecific small molecules. These are single small molecules with carefully designed dual pharmacology. Exscientia projects are already including this and an additional approach both in-house for Immuno-oncology (with Evotec), diabetes (with Sanofi) and psychiatric disease (Sumitomo Dainippon Pharma)."

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