Canada’s impending AI revolution and the opportunity for Canadian business

February 2017
The ability to acquire, organize, and draw conclusions from data with the help of Artificial intelligence will play a transformational role in business.

Acquire data
Organize data
Analyze data
Draw conclusion based on data
Make decision

Collect additional data based on decision outcomes to drive superior decision making through iteration.

External data supplements data set
AI helps drive superior decision-making and self-improving algorithms

Data science is the science of gathering data and using it to drive decision-making.

Recent advances in deep learning, a subset of AI, have led to an exponential increase in its ability to predict outcomes and make decisions.

Deep Learning’s ability to tackle problems over time

<table>
<thead>
<tr>
<th>Complexity of problems</th>
<th>Deep Learning capacity frontier</th>
<th>Predicted frontier</th>
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<tbody>
<tr>
<td>Google algorithms <strong>independently learn about concepts</strong> like people and cats by watching YouTube videos</td>
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<tr>
<td>The German <strong>traffic sign recognition benchmark competition</strong> is won by an <strong>algorithm</strong>, attaining better accuracy levels than humans</td>
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<td>Google produces its <strong>first self-driving car</strong></td>
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<td>AlphGo <strong>beats the world champion</strong> at the Chinese game of Go</td>
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<td>Libratius wins poker tournament against 4 top players, wins $1.8 million in the process</td>
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**Drivers**
- Better **hardware**
- **More data**
- Better algorithms and **training methods**

**SOURCE:** Press Search
Many technologies are developing and commercializing simultaneously giving rise to significant disruptive forces and a generation of new companies.

SOURCE: McKinsey Global Institute analysis

Artificial intelligence will underpin the next industrial revolution.
Artificial intelligence will create new markets and opportunities in industries ranging from healthcare to financial services

**Artificial intelligence will deliver most of its economic value by eliminating waste (e.g. asset underutilization) and creating surplus opportunities (e.g. accident avoidance, improved medical outcomes)**

<table>
<thead>
<tr>
<th>Industries</th>
<th>Example of opportunities</th>
</tr>
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<tbody>
<tr>
<td>Automotive &amp; Transport</td>
<td>▪ Autonomous vehicles to create a $87bn solutions market</td>
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<tr>
<td>Aerospace &amp; Defense</td>
<td>▪ Drone systems integration to create $82bn in positive economic impact and generate more than 100,000 jobs</td>
</tr>
<tr>
<td>Financial Services</td>
<td>▪ Robo-advisors expected to have ~$2.2tn in AUM by 2025</td>
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<td></td>
<td>▪ Personalized / dynamic financial advice and planning</td>
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<td>Healthcare</td>
<td>▪ Global market for telehealth to reach $34bn</td>
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<tr>
<td></td>
<td>▪ Global market for medical robotics to reach $18bn</td>
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<tr>
<td></td>
<td>▪ Possibility of better diagnostics personalized medicine</td>
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<tr>
<td>Agriculture</td>
<td>▪ Global agribot market to reach $16.3bn</td>
</tr>
<tr>
<td></td>
<td>▪ Significant improvements in yield management and better environmental management</td>
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</table>
To capture this opportunity, nations and corporations have already begun massively investing to build their own capabilities.

### Nations

- **$2.3bn** by 2016 in unclassified AI-related R&D
- **$1.2bn** for the development of AI in the next 5 years
- Made AI development a “national strategy” level priority (investment numbers not public)

### Corporations

- Purchased DeepMind, a 75-employee company, for **$500mn**
- **$1bn** in “Cognitive Technologies”, which includes Deep Learning as its core technology
- Deep Learning has become the central technology behind a large part of the service-offer of tech giants such as Google, Facebook, Samsung, IBM, and Panasonic

- Talent is a global market being exclusively tapped by a few early leaders;
- The price tag has gotten so high many organizations are essentially shut out from building capabilities from scratch

**SOURCE:** Press Search
By working together, Canada has the scale and expertise to win against leading global locations, but no single city is large enough on its own.

**PhD students graduating in AI per year**

<table>
<thead>
<tr>
<th>Location</th>
<th>81</th>
<th>51</th>
<th>39</th>
<th>84</th>
<th>57</th>
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<tbody>
<tr>
<td>Montreal</td>
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<tr>
<td>Toronto</td>
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<tr>
<td>Edmonton</td>
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**Total AI faculty**

<table>
<thead>
<tr>
<th>Location</th>
<th>73</th>
<th>46</th>
<th>35</th>
<th>76</th>
<th>51</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
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<tr>
<td>Silicon Valley</td>
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<tr>
<td>New York</td>
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<td>Boston</td>
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**AI expertise**

- **Deep Learning**
  - Montreal: Star
  - Toronto: Star
  - Edmonton: Check
  - Canada: Star

- **Reinforcement Learning**
  - Montreal: Check
  - Toronto: Check
  - Edmonton: Star
  - Canada: Check

- **Natural Language Processing**
  - Montreal: Star
  - Toronto: Star
  - Edmonton: Check
  - Canada: Star

- **Automatic Speech Recognition**
  - Montreal: Check
  - Toronto: Check
  - Edmonton: Check
  - Canada: Check

- **Computer Vision**
  - Montreal: Star
  - Toronto: Check
  - Edmonton: Check
  - Canada: Check

- **Deep commercialization ecosystem**
  - Montreal: Check
  - Toronto: Star
  - Edmonton: Check
  - Canada: Check

**SOURCE:** Press Search, Expert Interviews
Montreal has been a data science pioneer for the past 40 years

A base of leading research institutes in data science

<table>
<thead>
<tr>
<th>Institute</th>
<th>Founded Year</th>
<th>Description</th>
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<tbody>
<tr>
<td>MILA</td>
<td>1993</td>
<td>9 faculty professors, 40 students, 5 post-docs and 5 researchers conducting cutting-edge research on artificial intelligence. The Chair’s mission is to combine knowledge acquisition through Machine Learning with decision making through Mathematical Optimization in a unified approach.</td>
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<tr>
<td>CIRRELT</td>
<td>1971</td>
<td>70 experts on quantitative management, operational researchers, theoretical computer scientists, mathematicians and engineers.</td>
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<tr>
<td>GERAD</td>
<td>1979</td>
<td>57 researchers working on innovation, operation research, AI, applied mathematics and engineering.</td>
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<tr>
<td>UdeM</td>
<td>1966</td>
<td>1,500 visiting professors every year to work in its thirteen laboratories.</td>
</tr>
<tr>
<td>Polytechnique – Département de mathématiques et de génie industriel</td>
<td>1968</td>
<td>A team of 57 researchers working on innovation, operation research, AI, applied mathematics and engineering.</td>
</tr>
<tr>
<td>HEC - Département de sciences de la décision</td>
<td>1968</td>
<td>32 professors involved in mathematics for management (statistics, operation research, decision analysis, probabilities and financial mathematics).</td>
</tr>
<tr>
<td>UdeM – Département de l’information et de recherche opérationnelle</td>
<td>1966</td>
<td>Created in 1966 following the founding on the Université de Montréal’s first computer laboratory. Now brings together 40 researchers and 3 Canada Research Chairs.</td>
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</tbody>
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SOURCE: Web search
This culminated in 2016 when UdeM/HEC/Poly were awarded the Canada First Research Excellence grant in data science

Context

Awards
- In September 2016, IVADO received a $93.5 million grant from the Federal Government for deep learning research
- The award is the largest in the universities’ history
- Andrea Lodi received the Canada Excellence Research Chair in “Data Science for Real-Time Decision Making”

Commitment
- Develop fundamental research using massive data sets from which to draw useful information and develop actionable decisions
- Prioritize marketplace applications, industry partnerships and spin-offs in health, transportation, ICT, and energy networks

Why this matters
- UdeM, HEC, and Polytechnique worked together to secure Montreal’s leadership position in data science research
- A jury of academic peers selected Montreal, cementing Montreal’s global academic reputation
- Montreal has the funding to develop world-leading fundamental research in data science and artificial intelligence
- IVADO reached out to University of Alberta and McGill to collaborate
The CFREF grant consecrated the Montreal ecosystem as a leading hub in data science and artificial intelligence

#1 university hub in Canada
- At 900 researchers and doctoral students, Montreal has the biggest and most prestigious group of data sciences researchers in the world
- World-renowned academics, including Yoshua Bengio, one of the founding fathers of the deep learning movement
- The Institute for Data Valorisation (IVADO) was created to make Montréal a leader in data science and AI&OR
- Montreal got $93.5 million funding for AI&OR research funding through IVADO in 2016, on top of $140 million from partners

Leading start-ups & scale-ups
- Presence of Element AI, a world leading applied AI research company that launches AI-first solutions in partnership with large corporations
- Up to 2,600 startups with a pool of skilled talent of approximately 8,000 employees
- 125 technology-focused meet-up groups connected to startups and 45,000 members
- Large ecosystem of VC funds focused on pre-seed to growth equity
- Grassroots organizations such as MTL Data, Data Driven MTL, MTL Machine Learning

Strong corporate network
- Significant investments from Google, Amazon and Microsoft in the past year with a desire to make Montreal a central talent hub
- A robust data infrastructure system with at least 2,100 data specialists
- 91,000 ICT professionals and ranked 1st for lowest ICT business operating cost in software development
- Leading cloud / datacenter market in Canada; Amazon recently announced data center investment
- Headquarters to a number of large corporates looking to invest in data science and integrate it in their business models

SOURCE: Montréal International
To reach its full potential, the Montreal ecosystem must create opportunities to increase collaboration and promote commercialization.

Levers to reach full potential

**Large Companies**
- Define an AI/data strategy
- Build their AI and data teams and roadmaps
- Invest in research

**Universities**
- Attract leading faculties
- Train more data scientists and "AI-literate" applied scientists
- Create collaboration with Cies and governments

**Start-ups**
- Commercialize scalable ideas
- Contribute to the local AI enterprise solutions market

**Accelerators and VC investors**
- Funding
- Accompannement services to help startups scale

**Government**
- Provide funding to the ecosystem
- Implement friendly immigration, IP, data, and tax policies to help attract, train, and retain talent
- Provide access to government-owned data

Large companies to act as first-customers and/or acquire the most promising start-ups