Canada's Contributions to Deep Learning and Artificial Intelligence

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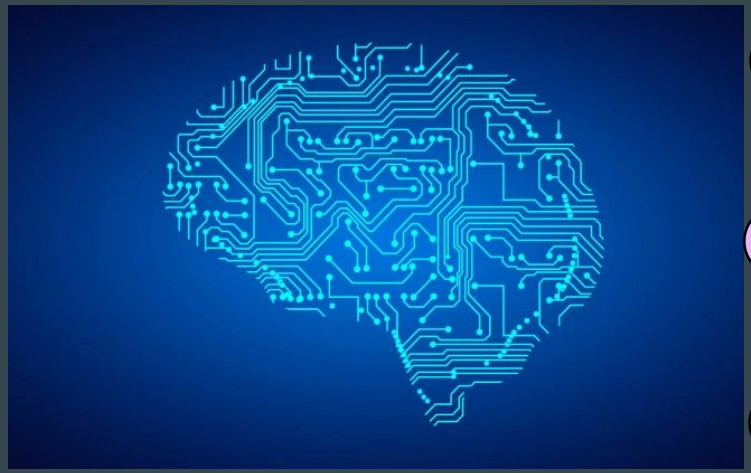
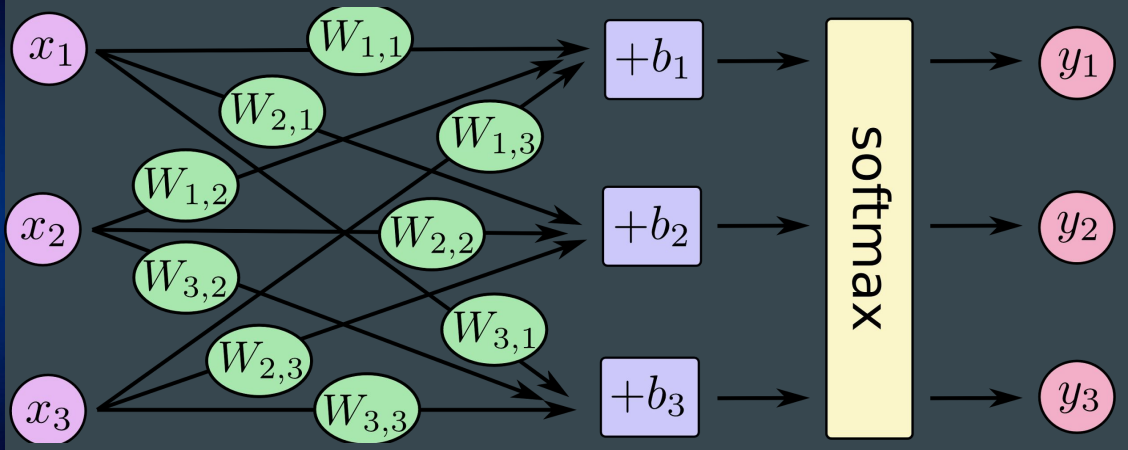
Self Introduction

- Academic Background
  - UBC - B.A. Political Science 2012
  - UBC - M.A. Political Science 2014
  - Univ. of Toronto - Master of Information 2017
- Currently at Univ. of Toronto - PhD in Information
  - Research Areas: knowledge graphs, linked data, machine learning, data science
- Work Experiences
  - TaLK Program - 2009 - 2010
  - Silicon Valley client - 2013 - 2017





Introduction to Deep Learning and Artificial Intelligence

Defining Artificial Intelligence

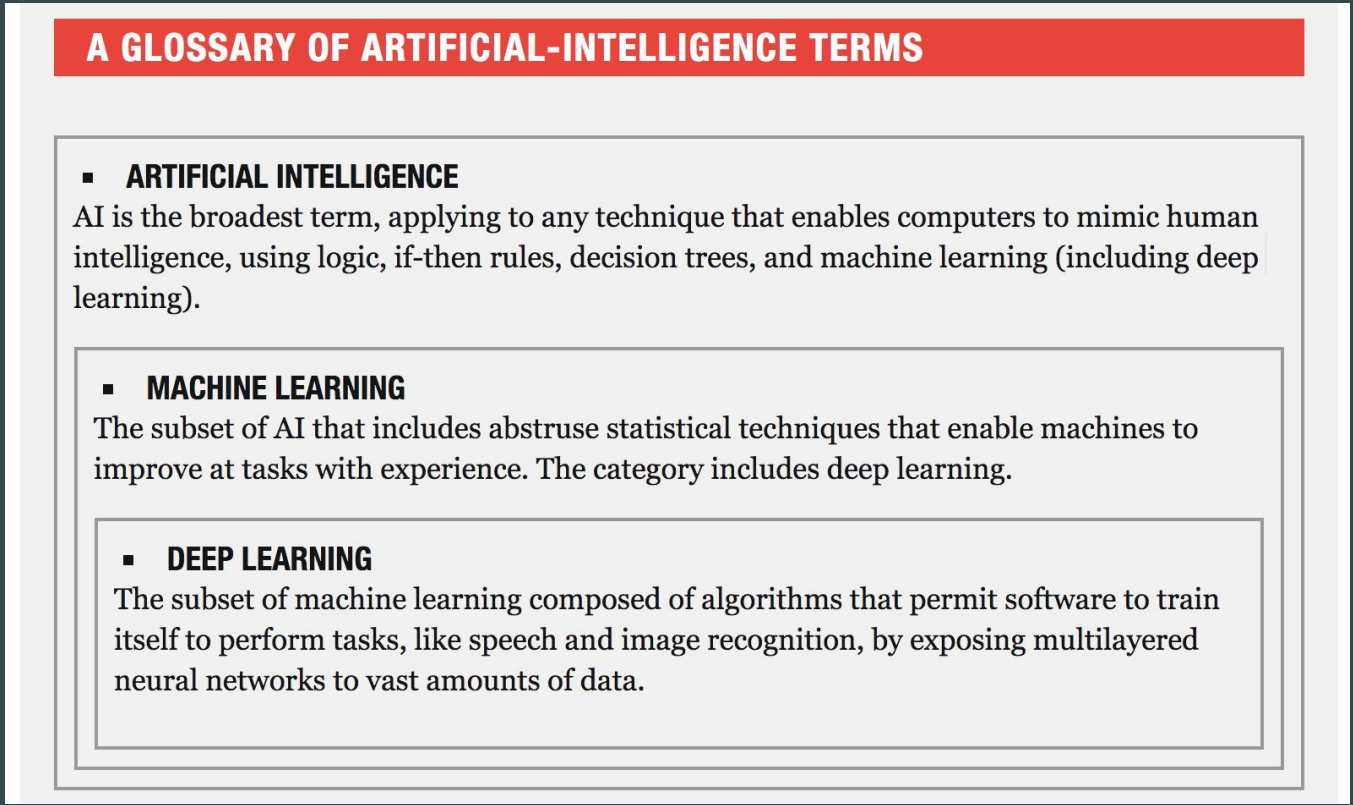
- According to one definition by Nils J. Nilsson, AI is:

  "Artificial intelligence is that activity devoted to making machines intelligent, and intelligence is that quality that enables an entity to function appropriately and with foresight in its environment."

- The 2016 Stanford AI Report comments on the dynamic nature of AI:

  "the field of AI is a continual endeavor to push forward the frontier of machine intelligence. Ironically, AI suffers the perennial fate of losing claim to its acquisitions, which eventually and inevitably get pulled inside the frontier..."

Defining Artificial Intelligence



A GLOSSARY OF ARTIFICIAL-INTELLIGENCE TERMS

- **ARTIFICIAL INTELLIGENCE**

AI is the broadest term, applying to any technique that enables computers to mimic human intelligence, using logic, if-then rules, decision trees, and machine learning (including deep learning).

- **MACHINE LEARNING**

The subset of AI that includes abstruse statistical techniques that enable machines to improve at tasks with experience. The category includes deep learning.

- **DEEP LEARNING**

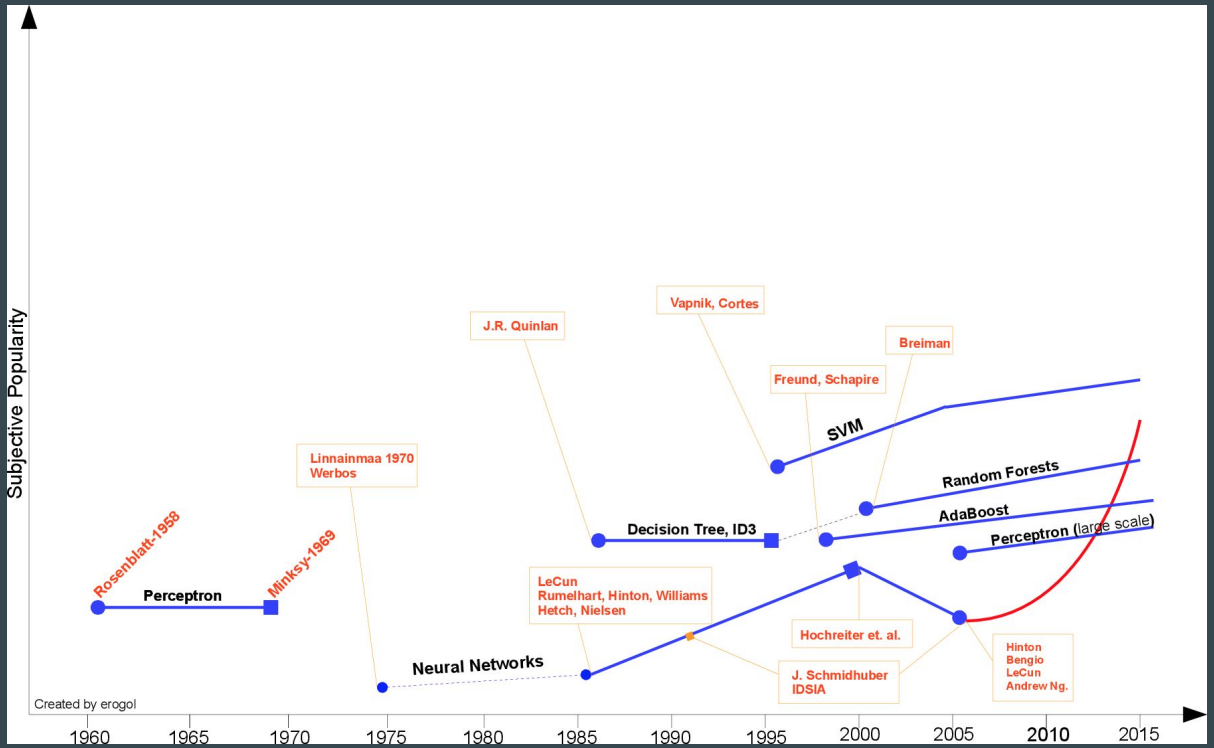
The subset of machine learning composed of algorithms that permit software to train itself to perform tasks, like speech and image recognition, by exposing multilayered neural networks to vast amounts of data.

Source: http://fortune.com/ai-artificial-intelligence-deep-machine-learning/

Historical Overview: A Rough Timeline

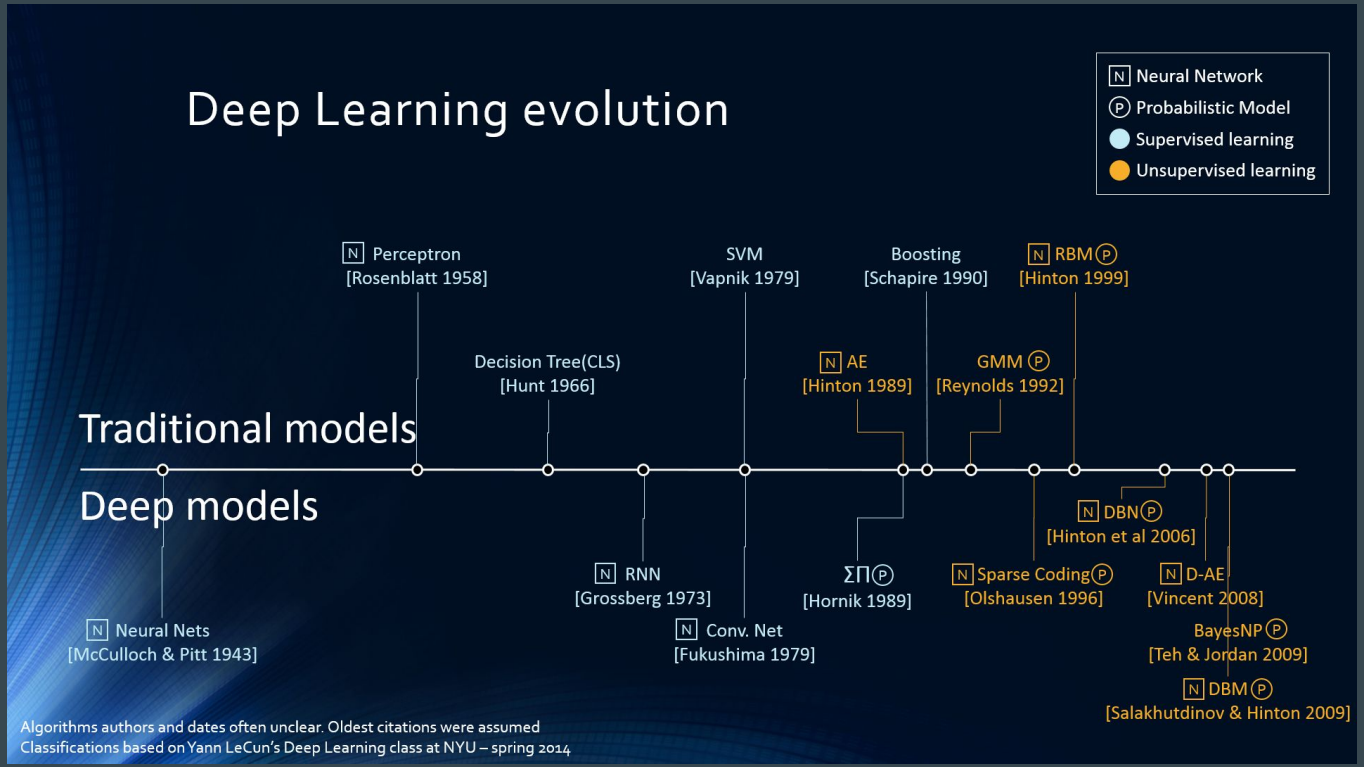
- 1943 - McCulloch-Pitts model of a neuron presented
- 1950 - Alan Turing proposes the "Turing Test"
- 1955 - John McCarthy coins the term "Artificial Intelligence"
- 1957 - Frank Rosenblatt develops the Perceptron, an early neural network
- 1959 - Arthur Samuel coins the term "Machine Learning"
- 1969 - Marvin Minsky & Seymour Papert's *Perceptrons* cast doubts on neural nets
- 1970s - 80s - Backpropagation is developed independently by many researchers
- 1970s - 80s - The AI Winters
- 1990s - Neural networks fall out of favour
- 2006 - Hinton et al. publish their Deep Belief Net
- 2000s - 2010s - Deep Learning advances with more *Nets:
    - AlexNet (2012), ResNet (2015), SyntaxNet (2016) ...

Visualizing this timeline



Source: Eren Golge, http://www.erogol.com/brief-history-machine-learning/

Another visualization



Source: Andrew Yuan, http://andrewyuan.github.io/

Historical Overview: Recent Innovations Leading to DL

> "The concept dates back to the 1950s, and many of the key algorithmic breakthroughs occurred in the 1980s and 1990s. What's changed is that today computer scientists have finally harnessed both **the vast computational power and the enormous storehouses of data**—images, video, audio, and text files strewn across the Internet—that, it turns out, are essential to making neural nets work well."
>
> - Parloff, R. (2016). Why Deep Learning is Suddenly Changing Your Life. Fortune.

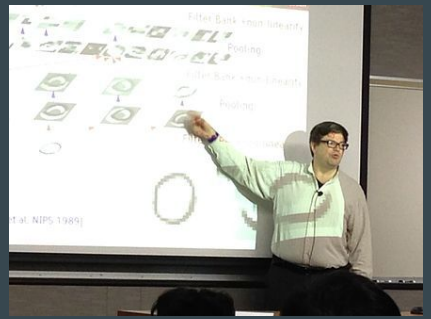
Source: http://fortune.com/ai-artificial-intelligence-deep-machine-learning/

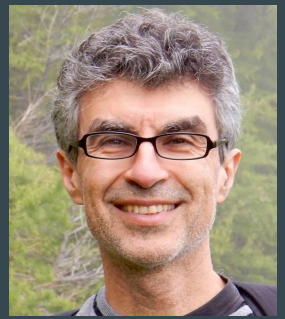
Historical Overview: Recent Innovations Leading to DL

- 1986 - Hinton et al. publish backpropagation paper
- 1989 - Yann LeCun implements a neural network to read handwritten digits
- 1997 - IBM Deep Blue victory in chess (not using neural networks)
- 1997 - Jürgen Schmidhuber and Sepp Hochreiter develop the LSTM
- 2006 - Hinton et al. publish their Deep Belief Net
- 2009 - Fei-Fei Li launches the ImageNet dataset of millions of labelled images
- 2011 - IBM Watson victory in Jeopardy (not using neural networks)
- 2012- AlexNet achieves 16% error rate (vs. ~25%) in ImageNet
- 2014 - Ian Goodfellow (Montréal) invents Generative Adversarial Networks
- 2016 - DeepMind AlphaGo defeats world champion Lee Sedol in Go 4-1

Canada's Contributions

- The "Canadian Mafia": Geoffrey Hinton, Yann LeCun, Yoshua Bengio
- Their research was supported by the Canadian Institute for Advanced Research (CIFAR) during the AI Winters when others abandoned neural networks
- Since 2004, Hinton has led the Learning in Machines & Brains program at CIFAR





"The CIFAR program created a community of researchers who could push the development of 'deep learning' ahead farther and faster than any of us could have done on our own."

- Geoffrey Hinton

Source: https://www.cifar.ca/assets/google-ddnresearch-geoffrey-hinton/

Canada’s Contributions

“Amazingly, the technology at the heart of these breakthroughs, Deep Learning, was largely developed in Canada. In fact, many of the world's AI leaders in both academia and at the world's most advanced technology companies – Google, Facebook, Apple, Open AI – came through the machine learning lab in the computer science department at the University of Toronto as PhD students, postdoctoral fellows or faculty.”

- Jacobs, Poutanen, Zemel, Hinton, and Clark. (2017). Artificial intelligence is the future, and Canada can seize it. The Globe and Mail.

Source:
https://beta.theglobeandmail.com/report-on-business/rob-commentary/artificial-intelligence-is-the-future-and-canada-must-seize-it

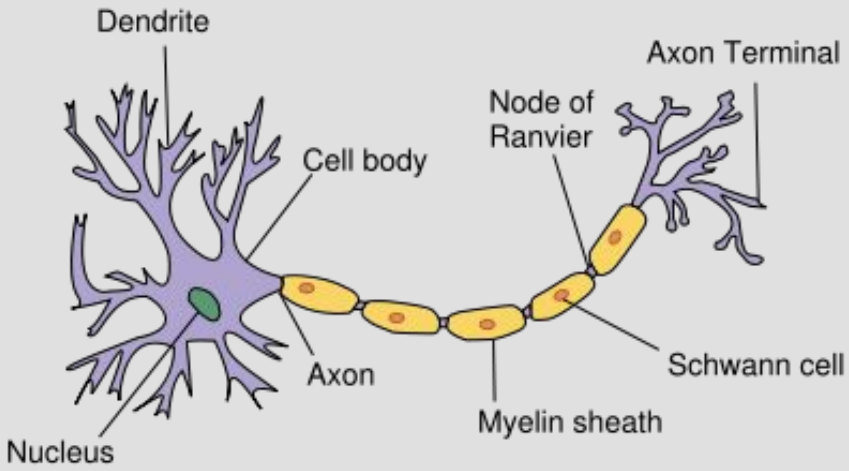
Canada's Contributions

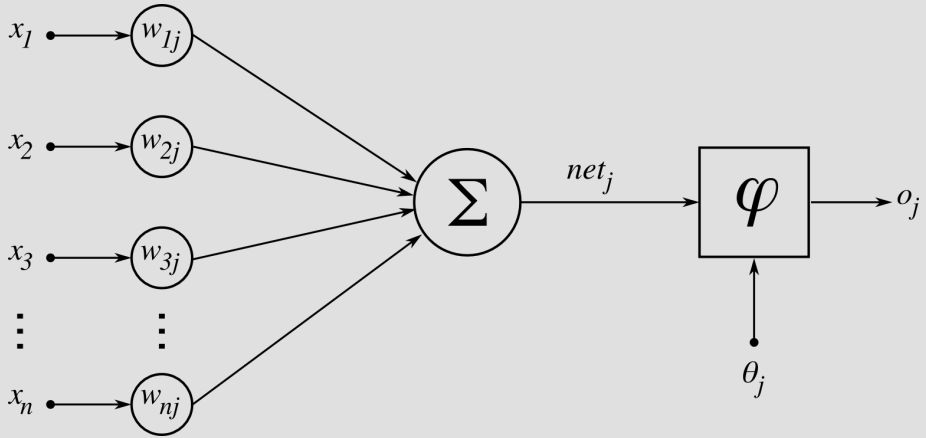
- Many are based at major tech companies
- Geoffrey Hinton
  - University of Toronto
  - Google, since 2013
- Yann LeCun
  - New York University
  - Facebook, since 2013
- Yoshua Bengio
  - University of Montreal
  - Microsoft (through Maluuba), since 2017
  - Students: Ian Goodfellow, Kyunghyun Cho ...

Deep Learning

Deep Learning: Theory

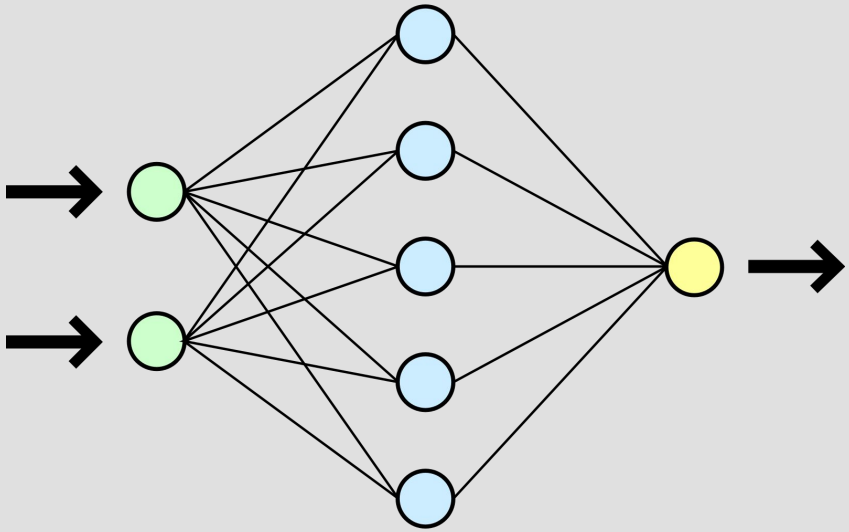
- A **neuron** – biological and artificial model

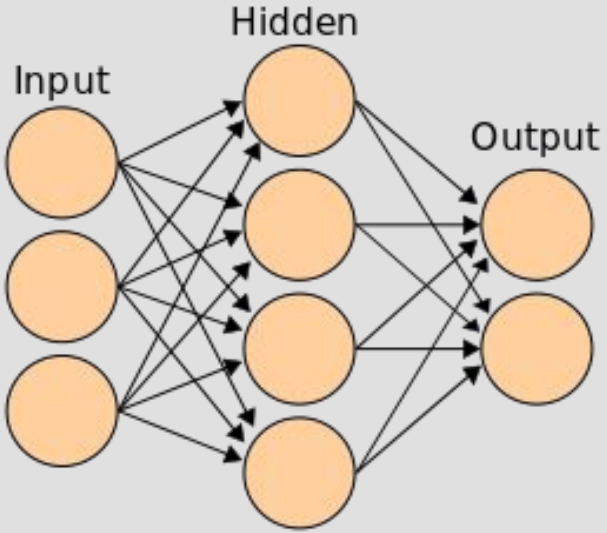




Deep Learning: Theory

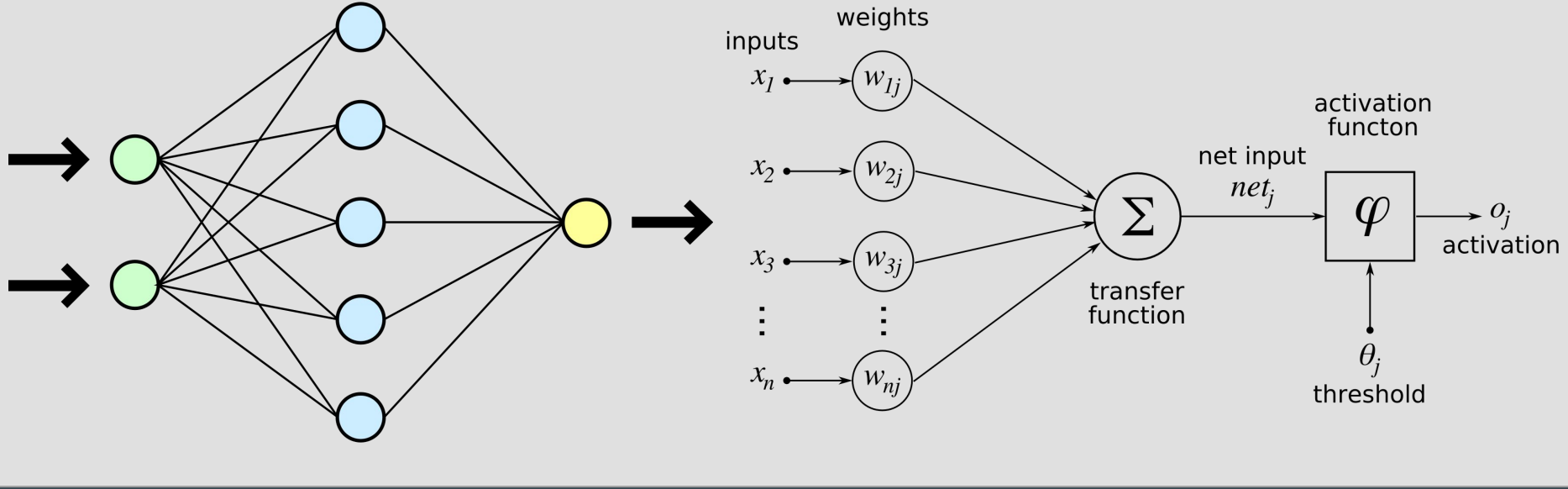
- A *Neural Network* combines many neurons into layers: *input, hidden, output*
- With Deep Learning, there can be up to hundreds of hidden layers



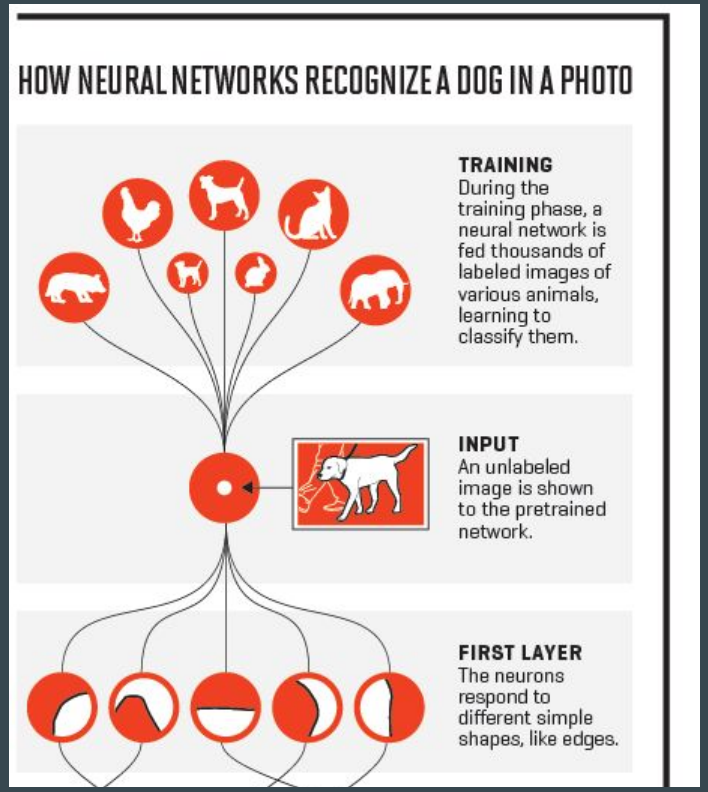


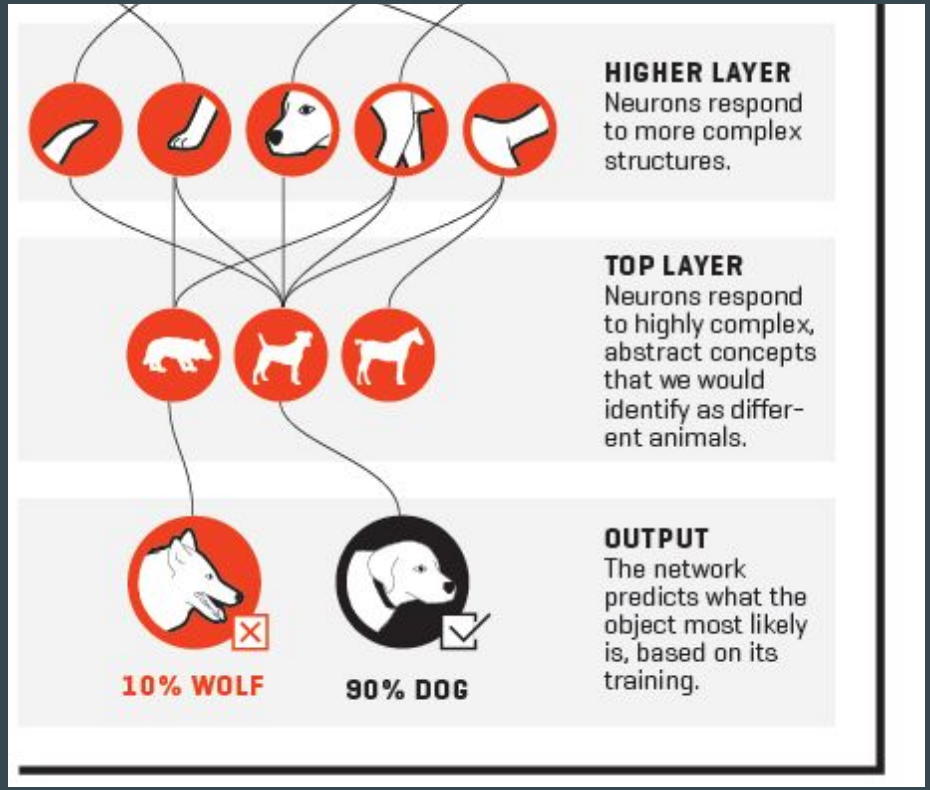
Deep Learning: Theory

- During *training*, the NN is given training data. With *backpropagation*, it learns the optimal *weights* and *biases* that reduce the *errors* on the training data.



Deep Learning: Theory

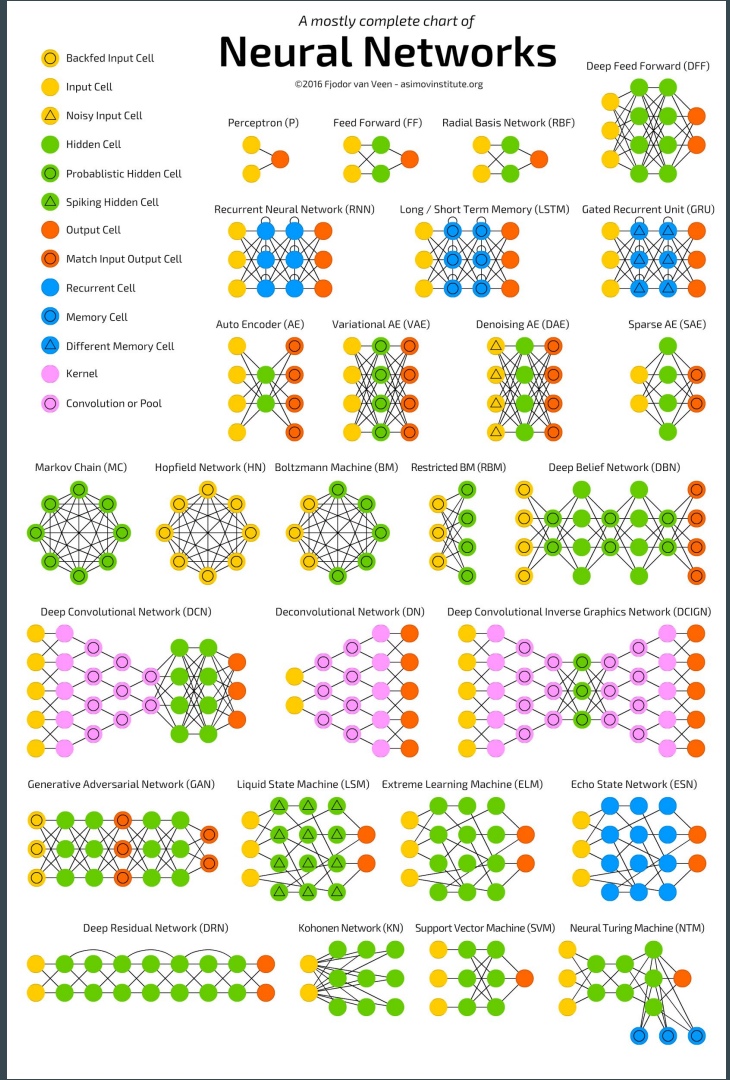




Source: http://fortune.com/ai-artificial-intelligence-deep-machine-learning/

Deep Learning: Theory

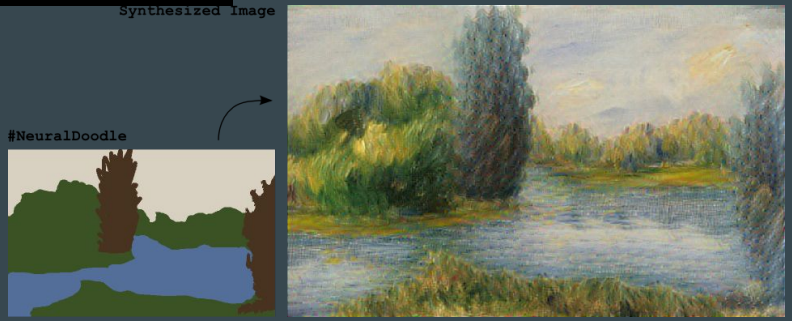
- There are many different variations of neural networks.



Deep Learning: Applications

- Deep Learning has been applied to many diverse fields including
  - computer vision
  - audio and speech recognition
  - natural language processing
  - machine translation

Deep Learning: Applications



Google's Neural Machine Translation

- Since 2006, Google Translate used a statistical machine translation system.

  "The old system worked the way all machine translation has worked for about 30 years: It sequestered each successive sentence fragment, looked up those words in a large statistically derived vocabulary table, then applied a battery of post-processing rules to affix proper endings and rearrange it all to make sense. The approach is called "phrase-based statistical machine translation," because by the time the system gets to the next phrase, it doesn't know what the last one was."

  - Lewis-Kraus, G. (2016). The Great A.I. Awakening. NYT

Source: https://www.nytimes.com/2016/12/14/magazine/the-great-ai-awakening.html

Google's Neural Machine Translation

- In 2016, on the 10 year anniversary of Google Translate, the work of hundreds of engineers was replaced by a neural network system.

  "At a high level, the Neural system translates whole sentences at a time, rather than just piece by piece. It uses this broader context to help it figure out the most relevant translation, which it then rearranges and adjusts to be more like a human speaking with proper grammar."

  - Turovsky, B. (2016). Found in translation: More accurate, fluent sentences in Google Translate. *Google Blog*.

Source: https://blog.google/products/translate/found-translation-more-accurate-fluent-sentences-google-translate/

Conclusion

- The field of AI is dynamic, and the definition changes.
- Canada’s contributions to Deep Learning significantly advanced AI.
- The Canadian government and universities supported Deep Learning research when it was not popular.

Q & A

Thank you!