Machine learning, Deep Learning, and Python

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What is machine learning?

- Put very informally, machine learning is a means to engineer knowledge or behaviour into a compute by providing examples rather than explicit programming.
- For example, in an email spam filter program, rather than explicitly programming rules that determine whether an email is *spam* or *ham*, we can use a machine learning algorithm and provide large number of examples of *spam* and *ham* and let the program learn the rules.
- Machine learning can be much more efficient at learning the rules than relying on explicit programming.
- It can arguably acquire knowledge that is impossible to explicitly program.

Examples of machine learning

- Recommender systems for YouTube, Amazon, Netflix
- Detecting credit card fraud
- Face identification, face recognition, object recognition
- Sentiment analysis
- Text classification and topic identification
- Natural language translation
- Game playing programs (e.g. AlphaGo)

Machine learning "algorithms"

- Often machine learning "algorithms" are reinventions or extensions of traditional statistical methods, e.g. nonlinear regression.
- However, machine learning's relationship with statistics is comparable to, say, computer science's relationship with electrical engineering, or neuroscience with psychology, etc.
- Machine learning obviously differs from applied statistics in ways such as:
  - A focus on real world engineering (often tech) problems rather than (scientific) data analysis.
  - Focus on large real-time systems, and so with a major focus on efficiency (e.g compare machine learning with computational statistics using Stan).
  - A major focus on prediction and "behaviour" rather than developing scientific models.
  - Side-stepping preoccupations with classical statistics like hypothesis tests, p-values
  - A new terminology (e.g. *features*, *inputs*, *targets*, *training*, rather than say *predictor variables*, *outcome variables*, *estimation*, *inference*, etc.).

Subdivisions of machine learning

- Machine learning is traditonally broken into three sub-divisions:
  - Supervised learning: Classification and regression, where explicit answers or "targets" corresponding to data examples are given.
  - Unsupervised learning: Statistical pattern identification and discovery. Data is provided and patterns are found. E.g. topic models, natural language grammar induction.
  - Reinforcement learning: Behaviours of an "agent" are rewarded or punished, leading to improved behaviours.

Deep learning

- Deep learning is another name, arguably a rebranding, of artificial neural networks, a technology originating in the 1950s.
- The first major artificial neural network technology were the perceptrons. In the 1980s, there were extended to multilayer perceptrons, which are a type of nonlinear regression.
- In the late 2000s, many artificial neural net technologies were increasingly scaled up to ever more “layers”, hence “deep”.
- Artificial neural nets were a side-show in machine learning until around 2010. Since then, they’ve been the toast of the town.

Why deep learning, why now?

- The following interrelated factors have all contributed to deep learning's growth:
  - Hardware. Deep learning models are very computationally demanding. GPUs are ideally suited to deep learning calculating and so cheap powerful GPUs have accelerated their performance.
  - Training data. Massive collections of texts, images, user data are now available.
  - Investment. Big tech, who often own the data, have invested heavily in deep learning.
  - Software. Tensorflow (Google), PyTorch (Facebook), Autograd have made using deep learning at scale easier.

Why Python?

- Why has Python become the lingua franca of machine learning?
- Arguably
  - It is widely taught in computer science.
  - It is a major language for the web back-end.
  - It has extensive scientific libraries.
- And then, as with R for computational statistics, it has benefited from a feedback loop of users and developers.