Background

Deep Learning

The study of artificial intelligence, which has recently been re-coined as machine intelligence to avoid the recent media hype, is composed of myriad of subfields with varying approaches for creating intelligent machines. The recent advances we have seen come from a particular subfield called machine learning, which teaches machines such that they can learn a function to generalize from data. This is paradigm of learning from data is called the *data-driven* approach. Within the field of machine learning, there are also a multitude of divisions for how to construct algorithms and teach them from data. The most prominent algorithms used today are artificial neural networks and in particular deep neural networks.

Artificial neural networks are types of algorithms that mimic the web of neurons in living organisms. In their most basic form, as with all machine learning algorithms, they compute some function given some input. The output that they produce can be a label identifying what the input is e.g. what is in an image, a number describing the input e.g. the price of a house, a data point that appears real e.g. a generated image of a cat. What differentiates ANN from other machine learning algorithms is their theoretical guarantee for being able to learn any function given by the Universal Approximation Theorem and computational efficiency by learning a distributed representation that allows that to learn hierarchical nature of data by inferring an exponential combination of features efficiently. These networks are anatomically organized into an input layer, one or more hidden layers, and an output layer.

Networks with more than two hidden layers are considered deep neural networks because they learn deep and rich representations of the data. What makes them especially appealing is that they learn these hierarchies automatically where as traditional machine learning techniques require manually engineering inputs for their algorithms. Additionally, deep networks have the inexplicable capability of being able to continuously improve their ability to generalize by increasing the number of hidden layers which has allowed them to outperform standard benchmark datasets and even human performance on comparable tasks.

Supervised Learning

Supervised learning is a general field and training paradigm that relies on a labeled data set, which is a collection of samples each associated with the correct answer. An example of a labeled sample is an image of a cat and the text “cat”, which labels the image. This is the most prominent type of learning today which has enable deep learning to become so powerful because companies such as Google, Facebook, Amazon, and Microsoft have been able to aggregate and organize years of their user data. Generally, the more data you have, the better the algorithms can generalize.

Unsupervised Learning

Unsupervised learning is a type of learning that does not use labels to tell the algorithm the correct answer. Samples in these datasets are considered unlabeled. This type of learning has not made as much progress as supervised learning and is an active area of research. The promise of unsupervised learning is tapping into the vast amounts of freely available unlabeled data on the internet without having to pay for manually labeled data, which is both time consuming and financially expensive. For example, there are millions of videos on YouTube, but the titles and meta information are not always indicative of the content in the videos and video frames are not labeled.

Semi-supervised Learning

One hope, however, is semi-supervised learning which could help when a data set may only contain some labels albeit in very small quantity. This type of learning has also not been extensively solved, but if it could it would begat even more progress in unsupervised learning and enable learning on obscure, rare, or personal data sets. Some recent progress has been with transfer learning and domain adaptation which leverage large labeled data sets to train a model which is then fine-tuned with the smaller data set for a different task on the smaller data set.