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Deep Learning: The power and promise of Computers that learn by example

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Abstract: Much of current Machine learning (ML) research has lost its connection to problems of important to the larger world of science and society and there exist glaring limitations in research. Conventional machine-learning techniques were limited in their ability to process natural data in their raw form. Deep learning, a new wave of machine learning research can both push forward its technical capabilities, while addressing areas of societal interest. Deep learning allows computational models that are composed of multiple processing layers to learn representations of data with multiple levels of abstraction. These methods have dramatically improved the state-of-the-art in speech recognition, visual object recognition, object detection and many other domains such as drug discovery and genomics, sequential data such as text and speech. The aim is to inspire ongoing discussion and focus on Deep learning that matters.

WHY DEEP LEARNING?

1958's Rosenblatt invention of the "Perceptron", a machine that can detect shapes through a network of neuron-like hardware units to the 2016's DeepMind's AlphaGo, an AI program that combines deep learning with Monte Carlo tree search, defeated 18 time international champion Lee Sedol in the game of Go, reaching a major AI milestone ten years ahead of schedule.

Machine-learning technology powers many aspects of modern society. from web searches to content filtering on social networks to recommendations on e-commerce websites, and it is increasingly present in consumer products. Machine-learning systems are used to identify objects in images, transcribe speech into text, match news items, posts or products with users' interests, and select relevant results of search. Conventional machine-learning techniques were limited in their ability to process natural data in their raw form. Increasingly, these applications make use deep learning.

First, majority of AI breakthroughs in recent years are due to deep learning. Second, deep learning is a broadly applicable AI technique not a specific breakthrough. Third, the technology industry is depending upon deep learning because of its step-function increase in performance and broad-based applications. Google, Facebook, Microsoft, Intel, IBM, Baidu, OpenAI, and various industry have made deep learning a central focus. Fourth, due to deep learning's low revenue base, large addressable market, and high growth rate.

DEEP LEARNING SIMPLIFIED

Artificial network is the capability of a machine to imitate intelligent human behaviour. It is accomplished by studying how human brain thinks, learn, work, decide while trying to solve problems like speech recognition, understanding natural language, image recognitions, and in recent areas of inventions in future prediction, self-driving car etc.

Machine learning is a type of AI that provides computer with ability to learn without being explicitly programmed. E.g. determine the species of flower just by reading sepal length, width, petal length, width.ML is categorised into Supervised learning, Unsupervised Learning, Reinforcement learning.ML is limited to small input and output data.ML can't solve complex problems like NLP, Image and handwriting recognition.

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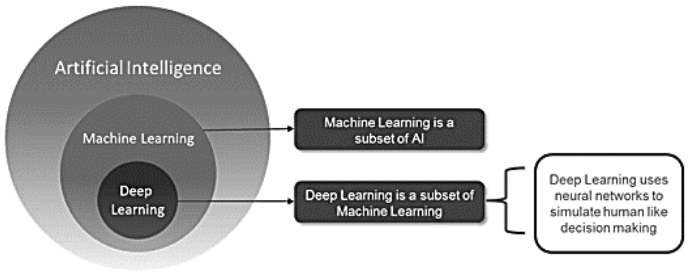
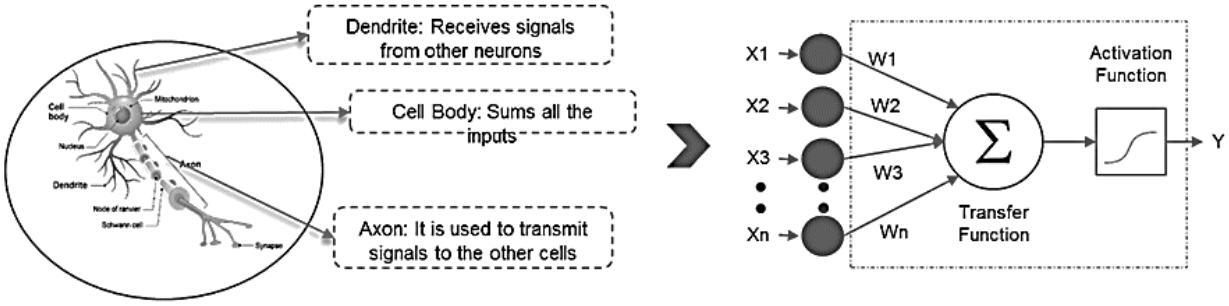


Fig1: Relationship Between Artificial Intelligence, Machine Learning, and Deep Learning

With the above limitations of both AI and ML, Deep Learning came into the rescue. DL models are capable to focus on the right features by themselves requiring little guidance from programmer. The idea behind DL is to build learning algorithms that mimics brain. The motivation behind DL is biological neuron network, that is neural network and biological principles was the Perceptron. It consists of statistical ML techniques used to learn features hierarchies based on neural network. Popular Applications of DL are Self driving car, Voice controlled assistance, Automatic image caption generation, Automatic machine translation, Predicting future. Deep learning has emerged as a new area of machine learning research and Deep learning is a modern name for an old technology-artificial neural networks.

DEEP LEARNING RE-ENGINEERING A HUMAN BRAIN

In an attempt to re-engineer a human brain, Deep Learning studies the basic unit of a brain called a brain cell or a neuron. Inspired from a neuron an artificial neuron or a perceptron was developed. If we focus on the structure of a biological neuron, it has dendrites which is used to receive inputs. These inputs are summed in the cell body and using the Axon it is passed on to the next biological neuron. A perceptron receives multiple inputs, applies various transformations and functions and provides an output.



Neuron Schematic for a neuron in a neural net

As we know that our brain consists of multiple connected neurons called neural network, we can also have a network of artificial neurons called perceptron to form a Deep neural network. Any Deep neural network will consist of three types of layers:

I. The Input Layer
II. The Hidden Layer
III. The Output Layer

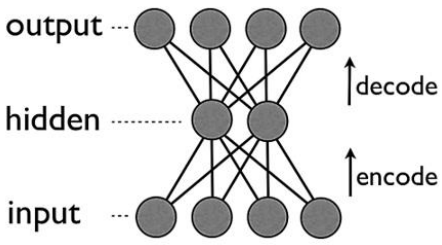


Fig 3: Architecture of an Autoencoder Neural Network

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The first layer is the input layer which receives all the inputs and the last layer is the output layer which provides the desired output. All the layers in between these layers are called hidden layers. There can be n number of hidden layers. The number of hidden layers and the number of perceptrons in each layer will entirely depend on the use-case you are trying to solve.

Now let's have a picture of a Deep Neural Networks, let's move ahead in this Deep Learning to get a high-level view of how Deep Neural Networks solves a problem. Deep learning seeks to learn rich hierarchical representations (i.e. features) automatically through multiple stages

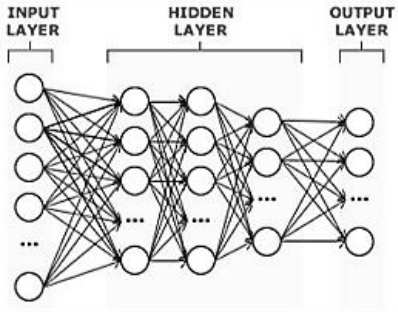

Fig 4: Architecture of a Multilayer Artificial Neural Network (ANN)

Each of the (non-output) layers is trained to be an auto-encoder. Basically, it is forced to learn good features that describe what comes from the previous layer an auto-encoder is trained, with an absolutely standard weight-adjustment algorithm to reproduce the input. By making this happen with (many) fewer units than the inputs, this forces the 'hidden layer' units to become good feature detectors. intermediate layers are each trained to be auto encoders (or similar). Final layer trained to predict class based on outputs from previous layers. That's the basic idea. There are many types of deep learning, different kinds of autoencoder, variations on architectures and training algorithms, etc.

THE FUTURE OF DEEP LEARNING

Unsupervised learning is affecting interest in deep learning and its effect is masked by supervised learning and expected to become far more important in the longer term like Human and animal unsupervised learning. Natural language understanding making impact over deep learning and is poised to make a large impact over the next few years. Progress in artificial intelligence will combine representation learning with complex reasoning. Although deep learning and simple reasoning have been used for speech and handwriting recognition for a long time, new paradigms are needed to replace rule-based manipulation operations on. New capabilities such as memory networks and generative networks could make deep learning far smarter, possibly providing a bridge to artificial general intelligence. In this a scenario, deep learning could make even the internet look small.

THE DEEP LEARNING OPPORTUNITY

Like the internet, deep learning is relevant for every industry, not just for the computing industry. Deep learning is highly disruptive, perhaps far more disruptive than the internet. The internet has been disruptive to media, advertising, retail, and enterprise software. Deep learning could change the manufacturing, automotive, health care, and finance industries dramatically. Deep learning enables computers to understand photos, translate language, diagnose diseases, forecast crops, and drive cars.

Deep learning is an open technology that anyone can use to build new applications, it can be done using a laptop and a few lines of Python code. While sizing new opportunities by their impact on established industries that emerged and flourished because of the internet, deep learning could create new use cases and companies that are impossible to foresee today. Deep learning could be a $17 trillion industry in 20 years.

THE LIMITS OF DEEP LEARNING

While finding applications in most industries, currently deep learning does not come close to general artificial intelligence or human intelligence.

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Today, powered by internet scale datasets and compute resources, deep learning is much more advanced, allowing networks to outperform humans in certain vision, speech, and game problems. Unsolved, however, are forms of intelligence beyond mere pattern recognition: the understanding of natural language, memory and recall, multi-step reasoning, and creativity. These problems involve intent, ambiguous sentences, and reasoning about outcomes, often drawing on knowledge about the real world. Today's commercial neural nets have no "general knowledge," no explicit memory system, and no ability to reason through multiple steps. Further, because neural nets are not programmed, a good question is how they arrive at their answers. This has been an obstacle to the adoption of deep learning in mission critical applications such as autonomous driving and health care.

Despite its progress to date, deep learning isn't standing still: new capabilities such as memory networks and generative networks could make deep learning far smarter, possibly providing a bridge to artificial general intelligence. In such a scenario, deep learning could make even the internet look small.

CONCLUSION

In sum, deep learning has becoming a new field of machine learning, and has gained extensive interests in different research area. It has shown some advantages over the traditional machine learning methods in some fields. Although deep learning works well in many machine learning tasks, it works equally poorly in some areas as the other learning methods.

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