Neural Networks

Lecture 19

Deep Neural Networks (1)

Md. Mijanur Rahman, Prof. Dr.

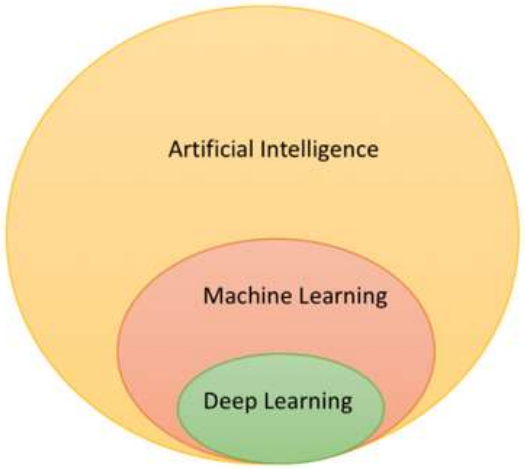
Dept. of Computer Science and Engineering, Jatiya Kabi Kazi Nazrul Islam University, Bangladesh. Email: mijan@ieee.org

Contents

- **This lecture covers the following topics:**
  - **Deep Learning**
  - **Deep Learning Process**
  - **Deep Neural Networks**

Deep Learning…

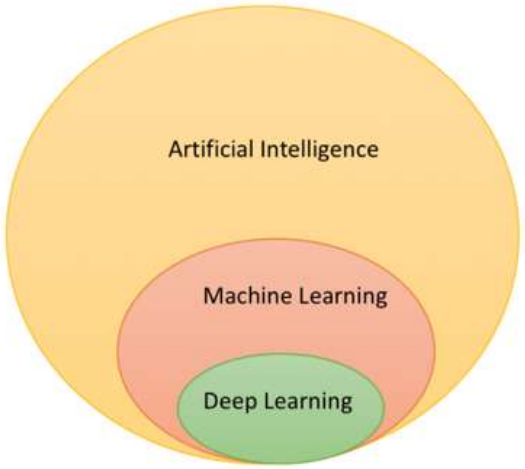
- Deep Learning is a sub-field of machine learning in Artificial intelligence (A.I.) that deals with algorithms inspired from the biological structure and functioning of a brain to aid machines with intelligence.
- Deep learning is an important element of data science, which includes statistics and **predictive modeling**.
- It is extremely beneficial to data scientists who are tasked with collecting, analyzing and interpreting large amounts of data; deep learning makes this process faster and easier.



Deep Learning…

- At its simplest, deep learning can be thought of as a way to automate **predictive analytics**.

- While traditional **machine learning algorithms** are linear, deep learning algorithms are stacked in a **hierarchy of increasing complexity and abstraction**.



Deep Learning

- To understand deep learning, imagine a toddler whose first word is *dog*. The toddler learns what a dog is -- and is not -- by pointing to objects and saying the word *dog*.
- The parent says, "Yes, that is a dog," or, "No, that is not a dog." As the toddler continues to point to objects, he becomes more aware of the features that all dogs possess.
- What the toddler does, without knowing it, is clarify a complex abstraction -- the concept of dog -- by building a hierarchy in which each level of abstraction is created with knowledge that was gained from the preceding layer of the hierarchy.

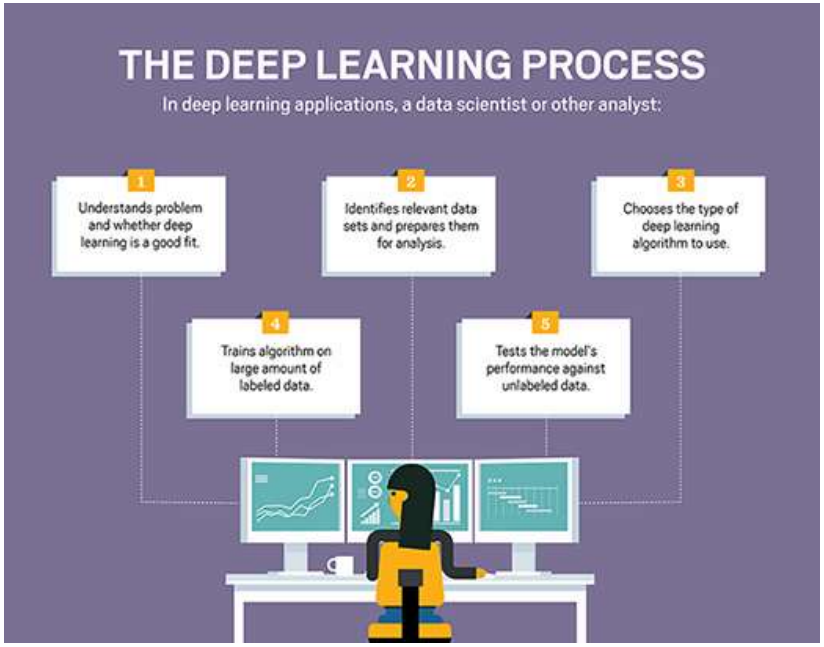
Machine Learning vs. Deep Learning…

- Deep learning is a subset of machine learning that differentiates itself through the way it solves problems. Machine learning requires a domain expert to identify most applied features.
- On the other hand, deep learning understands features incrementally, thus eliminating the need for domain expertise. This makes deep learning algorithms take much longer to train than machine learning algorithms, which only need a few seconds to a few hours.
- However, the reverse is true during testing. Deep learning algorithms take much less time to run tests than machine learning algorithms, whose test time increases along with the size of the data.
- Furthermore, machine learning does not require the same costly, high-end machines and high-performing GPUs that deep learning does.

Machine Learning vs. Deep Learning

- **Machine learning mostly performs poorly with image, audio, and other unstructured data types**.
- Say, classifying an image as a cat or dog or distinguishing audio clips as a male or female voice, etc.
- Deep Learning excelled at the new frontiers where machine learning was falling behind.
- In due course of time, additional research and experimentation led to the understanding where we could leverage deep learning for all machine learning tasks and expect better performance provided there was surplus data availability.
- Deep learning, therefore, became a ubiquitous field to solve predictive problems rather than just confined to areas of computer vision, speech, etc.

Deep Learning Process…



- **In deep learning, a data analyst:**

1. Understands problem and whether deep learning is a good fit.
2. Identifies relevant datasets and prepares them for analysis.
3. Choose the type of deep learning algorithm to use.
4. Trains algorithm on large amount of labeled data.
5. Tests the model's performance against unlabeled data.

Deep Learning Process

- **Examples of Deep learning in Application:**
- Because deep learning models process information in ways similar to the human brain, they can be applied to many tasks people do. Deep learning is currently used in most common image recognition tools, natural language processing (NLP) and speech recognition software.
- These tools are starting to appear in applications as diverse as self-driving cars and language translation services.
- Machine learning techniques have been widely applied in various areas such as pattern recognition, natural language processing, and computational learning.
- During the past decades, machine learning has brought enormous influence on our daily life with examples including efficient web search, self-driving systems, computer vision, and optical character recognition.

Deep Learning Neural Networks…

- A type of advanced machine learning algorithm, known as an *artificial neural network*, underpins most deep learning models.
- As a result, deep learning may sometimes be referred to as *deep neural learning* or *deep neural networking*.

- Especially, deep neural network models have become a powerful tool of machine learning and artificial intelligence.
- A deep neural network (DNN) is an artificial neural network (ANN) with multiple layers between the input and output layers.

Deep Learning Neural Networks

- Deep neural network models were originally inspired by neurobiology.
- On a high level, a biological neuron receives multiple signals through the synapses contacting its dendrites and sends a single stream of action potentials out through its axon.

- The complexity of multiple inputs is reduced by categorizing its input patterns.
- Inspired by this intuition, artificial neural network models are composed of *units* that combine multiple inputs and produce a single output.

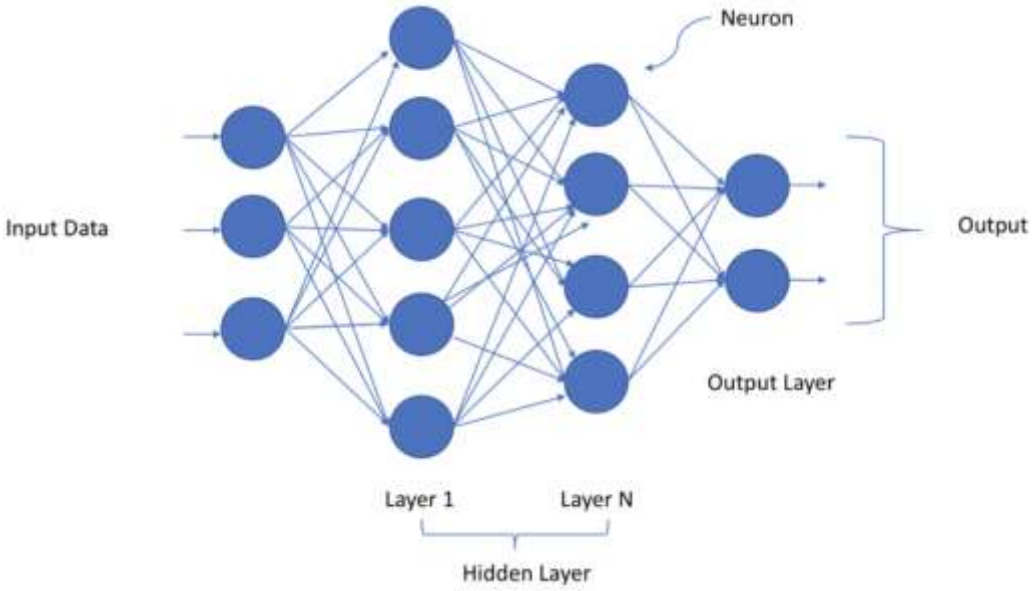
What makes a Neural Network “Deep”?

- Deep neural networks employ deep architectures in neural networks. **“Deep”** refers to functions with higher complexity in the number of layers and units in a single layer. The large datasets in the cloud made it possible to build more accurate models by using additional and larger layers to capture higher levels of patterns.
- The two phases of neural networks are called *training* (or learning) and *inference* (or prediction), and they refer to development versus production. The developer chooses the number of layers and the type of neural network, and training determines the weights.

- The name Deep Neural networks evolved from the use of many more hidden layers making it a ‘deep’ network to learn more complex patterns.

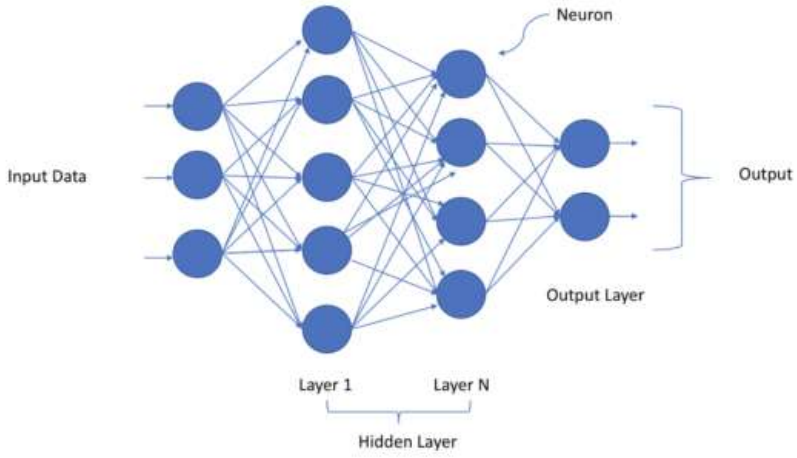
Decomposing a Deep Neural Network…

- A simplified version of Deep Neural Network is represented as a hierarchical (layered) organization of neurons (similar to the neurons in the brain) with connections to other neurons.
- These neurons pass a message or signal to other neurons based on the received input and form a complex network that learns with some feedback mechanism.
- The following diagram represents an 'N' layered Deep Neural Network.



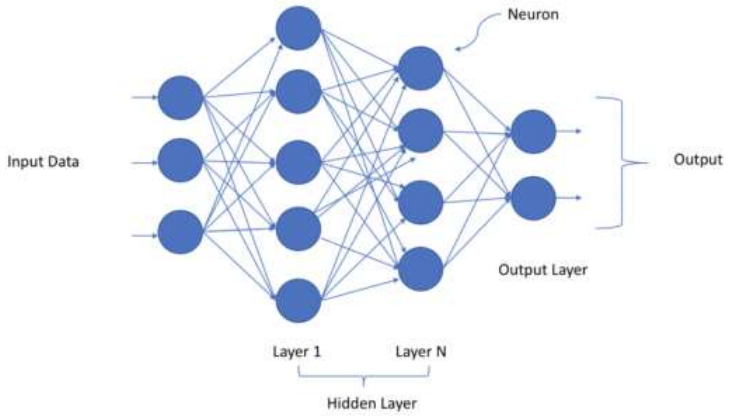
Decomposing a Deep Neural Network…

- The input data is consumed by the neurons in the first layer (not hidden) which then provide an output to the neurons within next layer and so on which provides the final output.
- The output might be a prediction like Yes or No (represented in probability).
- Each layer can have one or many neurons and each of them will compute a small function i.e. **activation function**.
- The activation function mimics the signal to pass to the next connected neurons.



Decomposing a Deep Neural Network

- **Decomposing the network, we can define few logical building blocks like:**
  - a neuron, layer,
  - weight,
  - input,
  - output,
  - an activation function and finally,
  - a learning mechanism (optimizer)



- that will help the neural network incrementally update the weights (that were randomly initialized) to a more suitable weight that aids into correct prediction of the outcome.

Types of Deep Neural Networks

- Three following types of deep neural networks are popularly used today:
  - **Multi-Layer Perceptron (MLP)**
    - A **multilayer perceptron** (**MLP**) is a fully connected class of feedforward artificial neural network (ANN).
  - **Convolutional Neural Network (CNN)**
    - A convolutional neural network (CNN or ConvNet) is **a network architecture for deep learning that learns directly from data**.
  - **Recurrent Neural Network (RNN)**
    - **Recurrent Neural Network**(**RNN**) is a type of Neural Network where the output from the previous step are fed as input to the current step. RNN works on the principle of saving the output of a particular layer and feeding this back to the input in order to predict the output of the layer.

Lecture 22: Deep Neural Networks (1)

DEEP NEURAL NETWORKS

To be continued…