Deep Learning

Introduction

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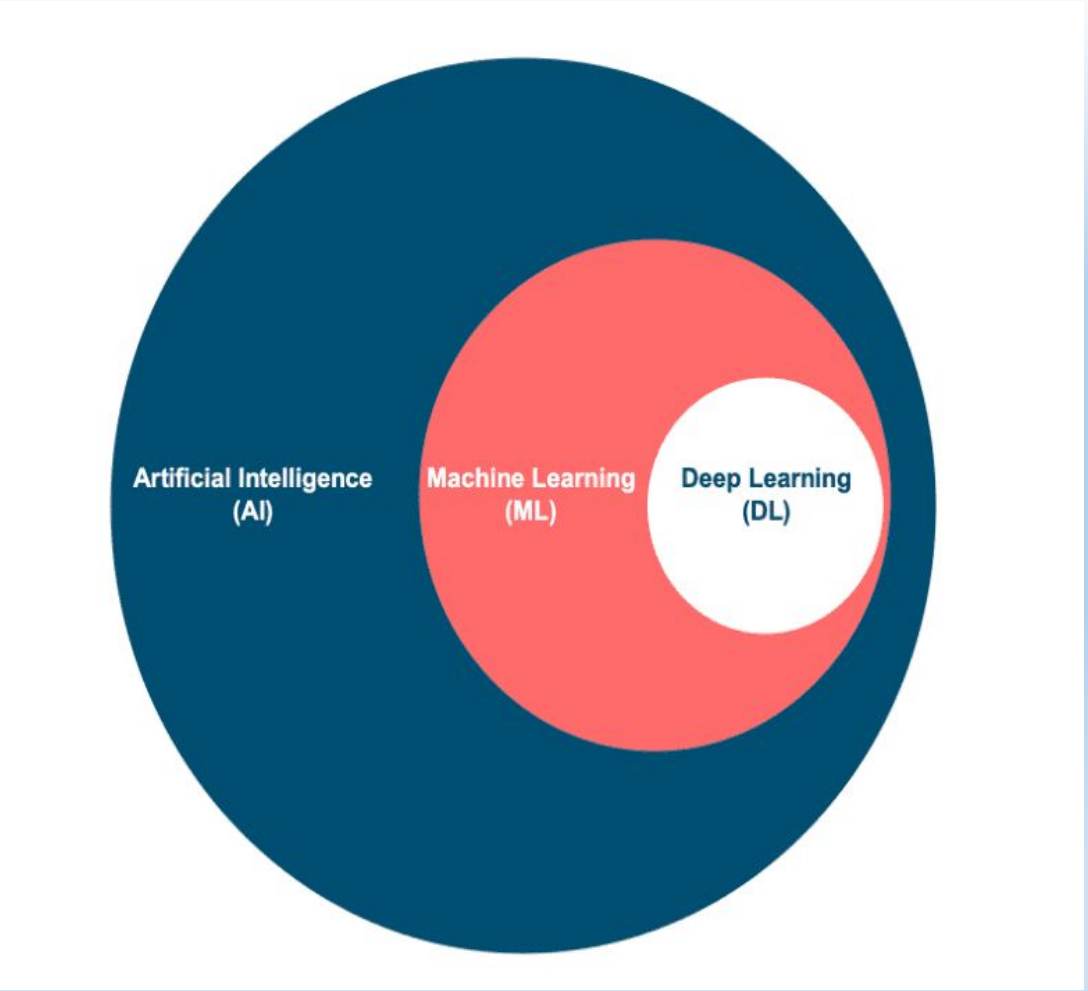
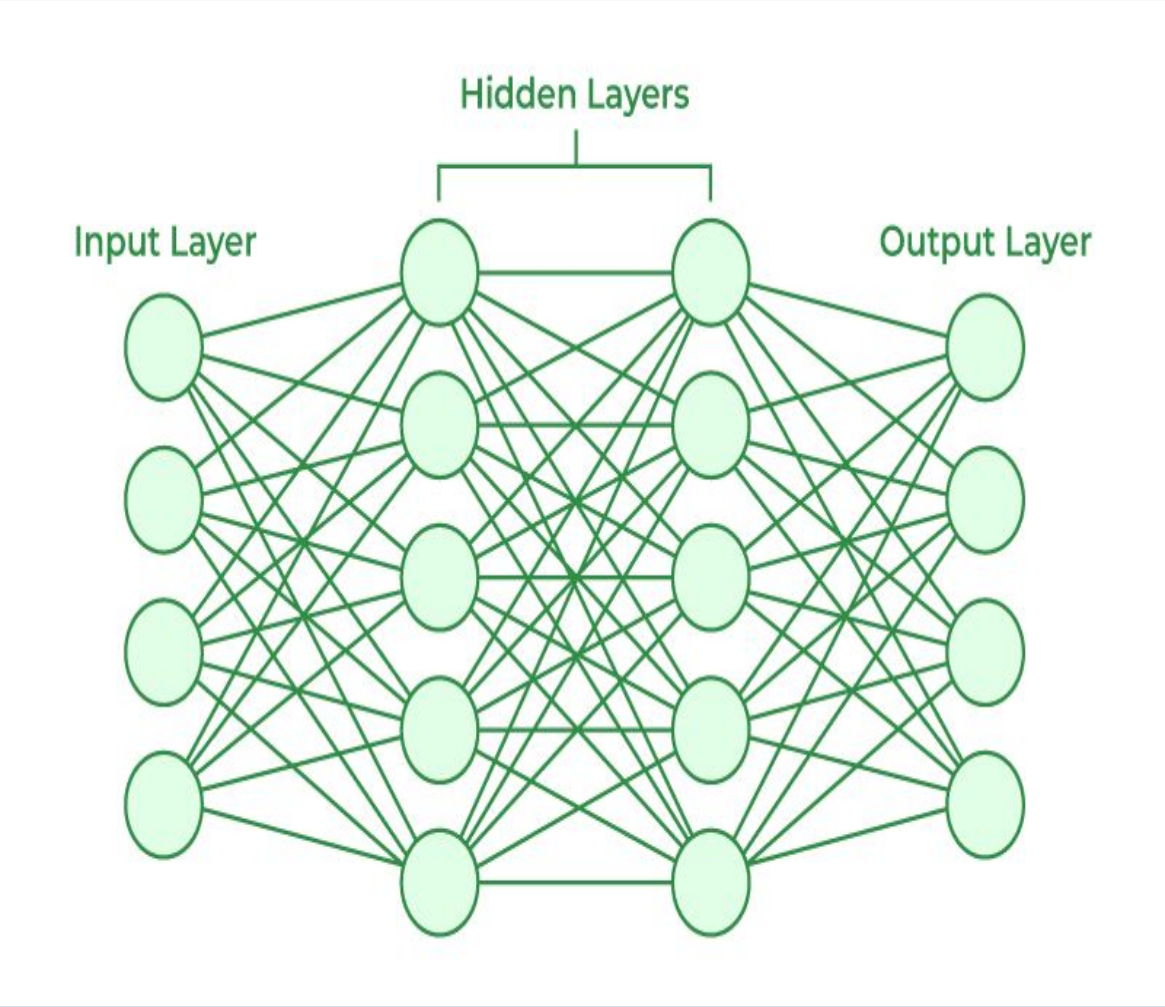
What is Deep learning?

- AI is intelligence demonstrated by machines, as opposed to natural intelligence displayed by animals including humans.
- ML is the study of computer algorithms that can improve automatically through experience and using data. It is seen as a part of artificial intelligence.
- DL is part of a broader family of machine learning methods based on artificial neural networks.



What is Deep learning? *cont.*

- Deep learning is a class of machine learning algorithms that use multiple layers of nonlinear processing units for feature extraction and transformation.
- Each successive layer uses the output from the previous layer as input to learn in supervised (e.g., classification) and/or unsupervised (e.g., pattern analysis) manners.
- It learns multiple levels of representations that correspond to different levels of abstraction.

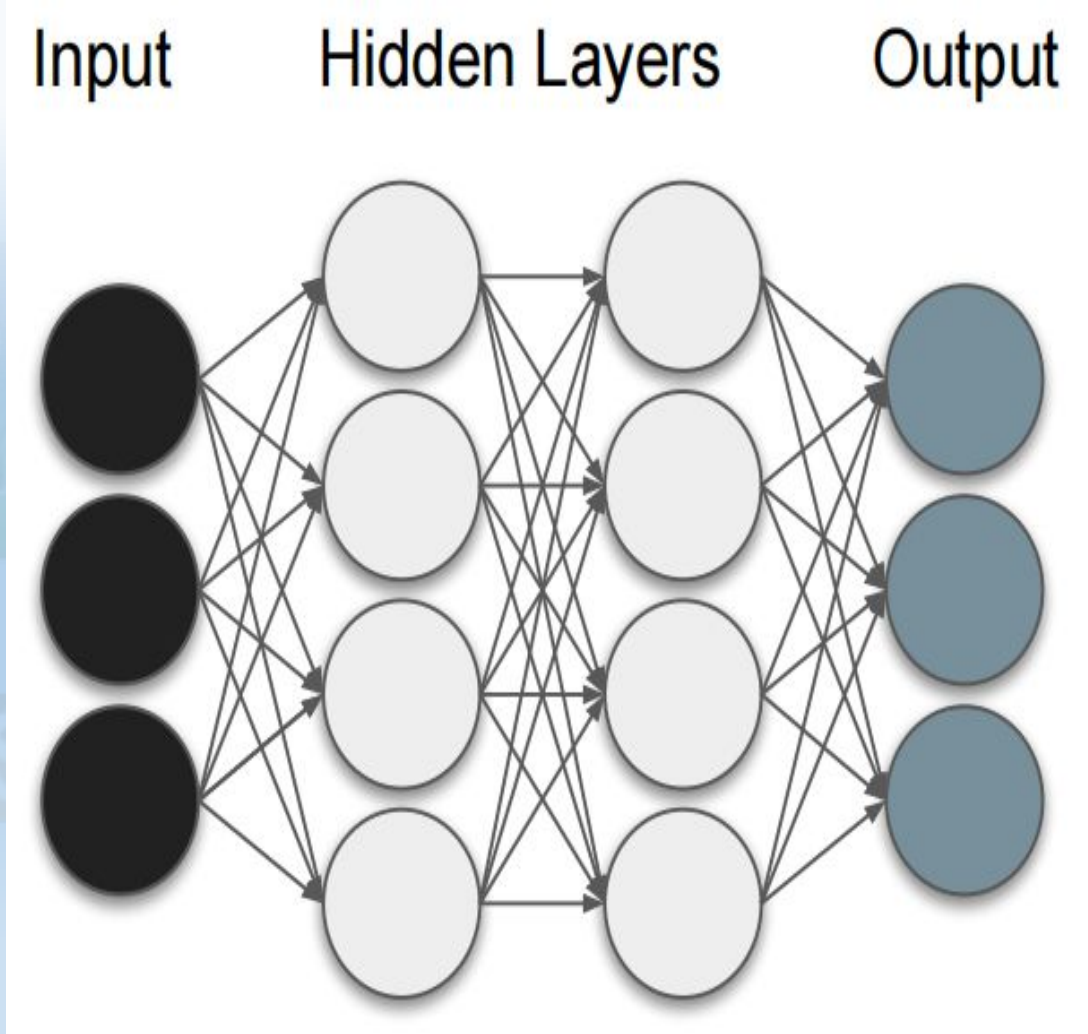


Why Deep Learning?

- Limitations of traditional machine learning algorithms
  - not good at handling high dimensional data.
  - difficult to do feature extraction and object recognition.
- Advantages of deep learning
  - DL is computationally expensive, but it is capable of handling high dimensional data.
  - feature extraction is done automatically.

Artificial Neural Network (ANN)

- ANNs are computer systems designed to mimic how the human brain processes information.
- These networks consist of layers of interconnected neurons that work together to solve complex problems.
- **Input Layer**: This is where the network receives information.
- **Hidden Layers**: These layers process the data received from the input layer. The more hidden layers there are, the more complex patterns the network can learn and understand. Each hidden layer transforms the data into more abstract information.
- **Output Layer**: This is where the final decision or prediction is made.



Types of ANN

1. Feedforward Neural Network (FNN)

Feedforward Neural Networks are one of the simplest types of ANNs. In this network, data flows in one direction from the input layer to the output layer, passing through one or more hidden layers. There are no loops or cycles means the data doesn't return to any earlier layers. This type of network does not use backpropagation and is mainly used for basic classification and regression tasks.

2. Convolutional Neural Network (CNN)

Convolutional Neural Networks (CNNs) are designed to process data that has a grid-like structure such as images. It include convolutional layers that apply filters to extract important features from the data such as edges or textures. This makes CNNs effective in image and speech recognition as they can identify patterns and structures in complex data.

3. Recurrent Neural Network (RNN)

Recurrent Neural Networks are designed to handle sequential data such as time-series or text. Unlike other networks, RNNs have feedback loops that allow information to be passed back into previous layers, giving the network memory. This feature helps RNNs to make predictions based on the context provided by previous data helps in making them ideal for tasks like speech recognition, language modeling and forecasting.

Applications of Artificial Neural Networks

- **Social Media**: ANNs help social media platforms suggest friends and relevant content by analyzing user profiles, interests and interactions.
- **Marketing and Sales**: E-commerce sites like Amazon use ANNs to recommend products based on browsing history.
- **Healthcare**: ANNs are used in medical imaging for detecting diseases like cancer and they assist in diagnosing conditions with accuracy similar to doctors.
- **Personal Assistants**: Virtual assistants like Siri and Alexa use ANNs to process natural language, understand voice commands and respond accordingly.
- **Customer Support:** ANNs power chatbots and automated customer service systems that analyze customer queries and provide accurate responses
- **Finance**: In the financial industry, they are used for fraud detection, credit scoring and predicting market trends by analyzing large sets of transaction data and spotting anomalies.

Challenges in Artificial Neural Networks

- **Data Dependency:** ANNs require large amounts of high-quality data to train effectively. Gathering and cleaning sufficient data can be time-consuming, expensive and often impractical.
- **Computational Power**: Training deep neural networks with many layers, demands significant computational resources.
- **Overfitting**: It can easily overfit to the training data which means they perform well on the training set but poorly on new, unseen data. This challenge arises when the model learns to memorize rather than generalize, reducing its real-world applicability.
- **Interpretability:** They are often referred to as "black boxes". It is difficult to understand how they make decisions which is a problem in fields like healthcare and finance where explainability and transparency are important.
- **Training Time**: Training ANNs can take a long time, especially for deep learning models with many layers and vast datasets