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Deep Learning : Artificial Neural Network, Types and Application

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ABSTRACT:

Deep learning is a powerful and flexible model for learning from data and solving complex tasks. However, not only one deep learning framework or method fits all problems. Therefore, it is important to understand deep learning models and their properties and how they can be applied in different fields. In this paper, we introduce the concept of deep learning, its basic design, and its types. We summarize the latest techniques and applications in deep learning in various fields. In addition, we discuss about artificial neural networks, neural network layers, and challenges in deep learning.

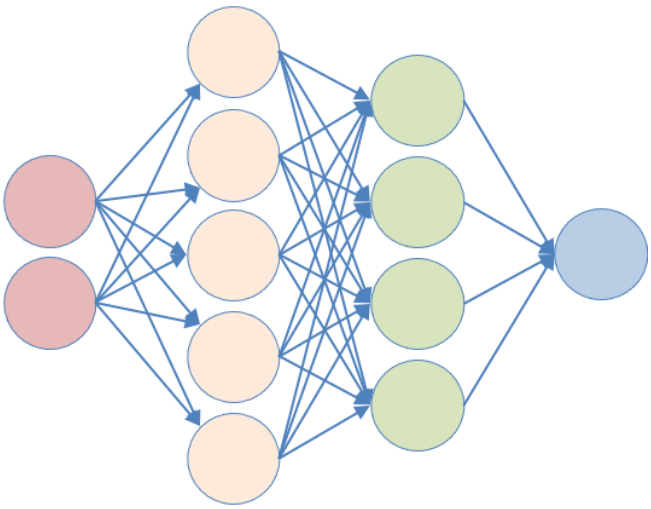
Introduction:

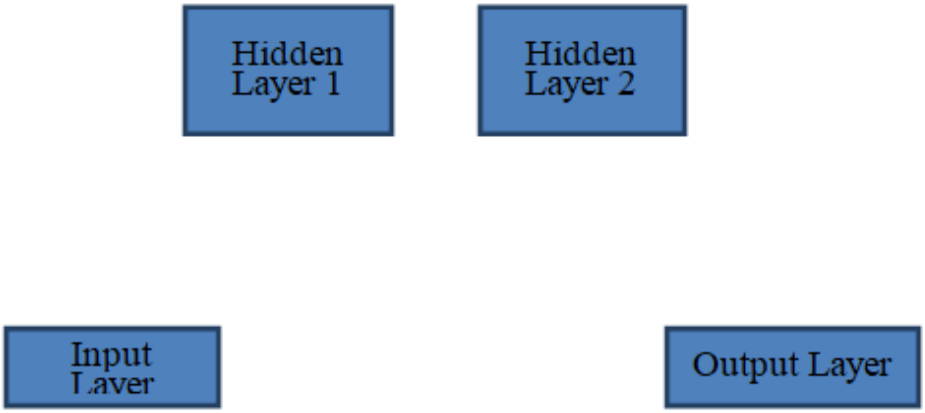
Deep learning is a branch of machine learning that is based on artificial neural networks. It is able to learn complex patterns and relationships in data. In deep learning, we don't need to explicitly explain program everything. It has become increasingly popular in recent years due to advances in computing power and the availability of large datasets. Because it is based on Artificial Neural Networks (ANN), also known as Deep Neural Networks (DNN). Inspired by the structure and function of biological neurons in the human brain, these neural networks are designed to learn from large amounts of data. A key characteristic of Deep Learning is to use the deep neural networks that have multiple layers of interconnected nodes. These networks can learn complex data representations by discovering hierarchical patterns and features in the data. Deep learning algorithms are design in a way that they can automatically learn and improve from data without the need to manually engineer features and Instruction.

Artificial Neural Network:

Artificial neural networks contain artificial neurons called units. These units are arranged in a series of layers, which together form the entire artificial neural network in the system. A layer can have only a dozen units or millions of units, depending on how complex the neural networks will be required to learn the hidden patterns in the data set. An artificial neural network normally has an input layer, an output layer, and also hidden layers. The input layer receives data from the outside world that the neural network needs to analyze or learn about. Then this data passes through one or more hidden layers that transform the input into data that is valuable to the output layer. Finally, the output layer provides the output in the form of the response of the artificial neural networks to the provided input data.

In a fully connected artificial neural network, there is an input layer and one or more hidden layers connected in series. Each neuron receives input from the neurons of the previous layer or the input layer. The output of one neuron becomes the input for other neurons in the next layer of the network, and this process continues until the last layer produces the output of the network. After passing through one or more hidden layers, this data is transformed into valuable data for the output layer. Finally, the output layer provides the output in the form of an artificial neural network's response to the incoming data.





Fully Connected Artificial Neural Network

Types Of Neural Network:

4.1 Convolutional Neural Network:

CNN stands for Convolutional Neural Network, which is a type of neural network in deep learning that uses convolutional layers to extract features and properties from images, videos, and other grid-like data The convolutional layer consists of a series of filters that slide across the input and feature- . By creating maps that represent the presence of shapes or features in the input CNNs can learn to recognize edges, shapes, colors, textures, and other visual features from data, and use them to create tasks such as images vision, object recognition, facial recognition , and computer vision. Let's delve into the details:

Convolution Layers: These form the first building block of CNN. As the name suggests, the main mathematical operation here is convolution. Convolutional layers apply filters on the input image to extract features. These filters draw over the image, detecting edges, textures, shapes and other shapes. The output of this layer is a set of feature maps representing features in an image.

Activation function: An activation function is applied after each convolution operation. A common operating unit is the Rectified Linear Unit (ReLU). It introduces nonlinearity into the network, allowing the identification of strong correlations between components.

Pooling Layer: The aim of the pooling layer is to down sample the characteristic maps. It reduces the spatial dimensions of the information, making computations greater green. Common pooling strategies encompass max pooling and average pooling.

Fully Connected Layers: These layers make the very last prediction. They take the excessive-stage capabilities extracted via the convolutional and pooling layers and combine them to categories or locate items. The community learns top of the line filters thru backpropagation and gradient descent.

4.2 Feedforward neural networks (FNNs):

FNN is the simplest type of Artificial Neural Network, with a linear flow of information through the network. This network has been widely used for tasks such as image classification, speech recognition, and natural language processing

Architecture: FNN network is made of interconnected neuron. Information flows only in one direction: from input nodes through hidden layers to output nodes. There will multiple layers can exists. No loops or cycles exist in the network.

Function Approximation: It is a FNNs approximate functions. For a given input, the network computes or predict an output based on learned weights .It is used for the tasks like pattern recognition, classification, and non-linear regression.

4.3 Recurrent Neural Networks (RNNs):

RNN are a type of neural network capable of processing sequential data such as time series and natural language. RNNs are able to maintain an the state that captures information about previous inputs, making them suitable for tasks such as speech recognition, natural language processing, and language translation. The RNN's defining feature is its hidden or memory state. This state holds information about the sequence it has encountered up to that point. At each step, the RNN processes the input data along with the hidden state from the previous step. This enables it to capture long-range dependencies within the sequence.

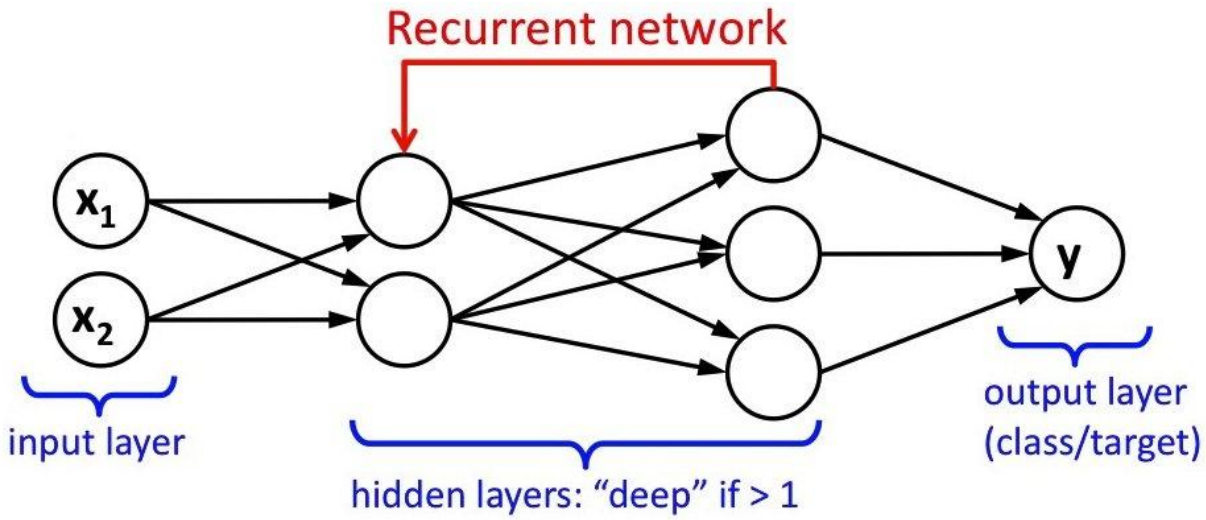
RNN architectures vary in input and output scenarios: -

One-to-One: A basic neural network with one input and one output.

One-to-Many: One input generates multiple related outputs, like captioning images.

Many-to-One: Multiple inputs result in a single output, often used in sentiment analysis.

Many-to-Many: Handles multiple inputs and outputs, commonly used for sequence-to-sequence translation tasks.



TYPES OF LEARNING:

Supervised Machine Learning:

Supervised machine learning is a technique in which a neural network learns to predict or classify data based on labeled datasets. Here we specify both input functions along with target variables. the neural network learns to make predictions based on the cost or error that comes from the difference between the predicted and actual target, a process known as backpropagation. Deep learning algorithms like Convolutional Neural Networks, Recurrent Neural Networks are used for many supervised tasks like image classification and recognition, sentiment analysis, language translation, etc.

Unsupervised Machine Learning:

Unsupervised machine learning is a machine learning technique in which neural networks learn to discover patterns or find clustered datasets based on unlabeled datasets. There are no target variables here. On the other hand, machines must determine hidden patterns and relationships in data sets. Deep learning algorithms such as auto encoders and generative models are used for unsupervised tasks such as clustering, dimensionality reduction, and anomaly detection.

Reinforcement Machine Learning:

Reinforcement machine learning is a machine learning technique in which an agent learns to make decisions to maximize reward signals in its environment. Agents interact with the environment by performing actions and observing the resulting rewards. Deep learning can be used to learn policies or sequences of actions that maximize cumulative reward over time. Deep reinforcement learning algorithms, such as Deep Q and Deep Deterministic Policy Gradient (DDPG) networks, are used to improve tasks such as robotics and gameplay.

DIFFERENCE BETWEEN MACHINE LEARNING AND DEEP LEARNING

MACHINE LEARNING	DEEP LEARNING
We apply the statistical algorithms to learn the hidden patterns and relationships within the dataset.	It Use the artificial neural network architecture to learn the hidden patterns and relationships in the dataset.
It can be work on the smaller amount of dataset to train model.	It requires the big dataset with compare to machine learning model.
Better work for simple and low-label task. Like regression and prediction.	Better for complex task and big dataset like image processing, natural language processing.
Machine learning model takes less time to train the model with dataset.	Because of the big dataset it takes more time to train the model.
The model is built using relevant features that are manually extracted from the images to detect the object in the image.	Relevant features are automatically extracted from images. It's a learning process from start to finish.
Less complex train fast and easy to interpret the result	More complex, Required huge dataset for more accuracy
It can work on the CPU and requires less computing power as compared to deep learning models.	For complex computing It requires a high-performance computer with GPU.

APPLICATION OF DEEP LEARNING:

Deep learning application are mostly used in computer vision, image processing and reinforcement learning.

Computer Vision:

In computer vision, deep learning models can enable machines to identify and understand visual data. Some of the major applications of deep learning in computer vision include:

- **Object detection and recognition**: A deep learning model can be used to identify and localize objects in images and videos, enabling machines to perform tasks such as self-driving cars, surveillance and robotics.
- **Image classification:** Deep learning models can be used to classify images into categories such as animals, plants and buildings. This is used in applications such as medical imaging, quality control and image retrieval.
- **Image Segmentation**: Deep learning models can be used to segment an image into different regions, allowing specific features in images to be identified.

Natural Language Processing (NLP):

In NLP, deep learning models enable machines to understand and reproduce human language. The main applications of deep learning in NLP are:

- **Automatic text generation** : Deep learning models can learn a collection of texts and use these trained models to automatically generate new texts such as summaries and articles.
- **Language translation**: Deep learning models can translate text from one language to another, allowing you to communicate with people from different language backgrounds.
- **Sentiment analysis**: Deep learning models analyze the sentiment of the text and allow you to determine whether the text is positive, negative or neutral. It is used in applications such as customer service, social media monitoring, and political analysis.
- **Speech recognition**: Deep learning models can recognize and transcribe spoken words, enabling them to perform tasks such as speech-to-text, voice search, and voice-controlled devices.

Reinforcement Learning:

In reinforcement learning, deep learning acts as training agents that take actions in the environment to maximize reward. Some of the main applications of deep learning in reinforcement learning include:

- **Gameplay**: Deep reinforcement learning models have been able to beat human experts in games like Go, Chess and Atari.
- **Robotics**: Deep reinforcement learning models can be used to train robots to perform complex tasks such as grasping, navigating, and manipulating objects.
- **Control systems**: Use deep reinforcement learning models to control complex systems such as power grids, traffic management, and supply chain optimization.

CONCLUSION:

In this article, we have presented a structured and comprehensive view of deep learning technology, which is considered a core part of artificial intelligence. It begins with the simple artificial neural network model and moves to the modern techniques of deep learning. Deep learning, as opposed to traditional machine learning and data mining algorithms, can produce extremely high level representation of data from vast amounts of raw data. In this we explore all the three learning methods of deep learning . Supervised learning , Unsupervised learning and Reinforcement learning. At the last of paper we Discuss three most important application of deep learning, Computer Vision, Natural Language Processing and Reinforcement learning.

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