

Applications of neural networks in different fields

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Abstract. In the realm of modern technology, the rapid advancements in neural networks have ignited transformative shifts across various domains. This essay explores the multifaceted impacts of neural networks on technology, shedding light on their application in diverse sectors. The discussion encompasses the foundational principles of neural networks, including supervised and unsupervised learning, as well as their intersection with cutting-edge techniques. The essay elucidates the role of neural networks in fostering artificial intelligence, enabling autonomous systems, enhancing healthcare diagnostics, and revolutionizing natural language processing. Additionally, it delves into the ethical considerations and challenges presented by these technologies. This paper encapsulates the exploration of neural networks' rise from theoretical constructs to instrumental agents of change in the technological landscape, inviting readers to delve into the intricate interplay between innovation and its implications.

Keywords: Neural network, deep learning, machine learning, Long Short Term Memory Networks (LSTMs), k means, clustering.

1. Introduction

The best-performing AI systems of the last 10 years have been produced by continuous optimization of deep learning techniques, such as speech recognizers, and the latest version of Google's automatic translator. Neural networks, a form of artificial intelligence, enable computers to process data in a manner inspired by the human brain. This machine learning technique, also known as deep learning, involves the use of interconnected nodes or neurons arranged hierarchically, mimicking the structure of the human brain. These adaptive systems allow computers to learn from their mistakes and improve over time. Consequently, artificial neural networks are capable of tackling complex tasks such as document summarization and image or facial recognition [1]. Computationally, a neural network consists of numerous artificial neurons connected together, and it often possesses the ability to modify its internal structure based on external information, making it an adaptive system. On the other hand, the machine learning framework is very large. It usually uses linear regression, logistic regression, decision trees, SVM, etc., including deep learning (neural networks), all of which belong to the category of machine learning. Machine learning is the process of acquiring knowledge through experience and is a field that focuses on inductive algorithms and other algorithms that can be called "learning". Neural networks, on the other hand, are a subset of machine learning that is realized through a number of algorithmic procedures acquired while learning neural networks. A neural network consists of a simple processing unit that communicates by sending signals to each other through a large number of weighted connections. The system is inherently parallel, meaning that many

units can perform computations at the same time [2-3]. Therefore, the aim of this paper is to show the role of neural networks in facilitating artificial intelligence, realizing autonomous systems, changing aspects of natural language processing, and enhancing medical diagnosis. The ethical considerations and challenges arising from the enhancement of neural network technology are also examined. Based on the analysis of the article, the authors hope to provide more reflections on the impact of neural network development on societal change, so as to better facilitate the exploration of neural network technology.

2. Neural Network

The neural network is an extension of the perceptron and the Deep-Learning Neural Network (DNN) can be understood as a neural network with multiple hidden layers. The terms "multi-layer neural network" and "deep neural network" (DNN) essentially refer to the same concept, and DNN is sometimes referred to as Multi-Layer Perceptron (MLP). Deep learning is essentially a modern term for an artificial intelligence approach known as neural networks, which have been in and out of popularity for over 70 years. The concept of neural networks was initially proposed in 1944 by Warren McCulloch and Walter Pitts, who were researchers at the University of Chicago and later became founding members of what is sometimes regarded as the first cognitive science department at MIT in 1952 [4-5].

Neural networks are extensions of perceptrons, and DNNs can be understood as neural networks with multiple hidden layers. Multilayer neural networks and DNNs actually refer to the same thing, and DNNs are sometimes called Multi-Layer Perceptrons (MLP). Deep learning is the new name for neural networks, which have been evolving over the past 70+ years. Neural networks were first proposed by McCulloch and Pitts in 1944. The neural network structure resembles that of the human brain and comprises artificial neurons, also known as nodes, organized in three adjacent layers [3,5]. Within a Deep-Learning Neural Network (DNN), the neural network layers can be classified into three types based on their positions: input layer, hidden layer, and output layer, as illustrated in Figure 1. Typically, the first layer functions as the input layer, the last layer serves as the output layer, and the layers in between are referred to as hidden layers. These layers are fully connected, meaning that every neuron in the i -th layer is linked to every neuron in the $i+1$ th layer. Despite the apparent complexity of DNN, it can still be viewed as a localized, scaled-down model of the perceptron, i.e., a linear relationship ($z = \sum w_i x_i + b$).

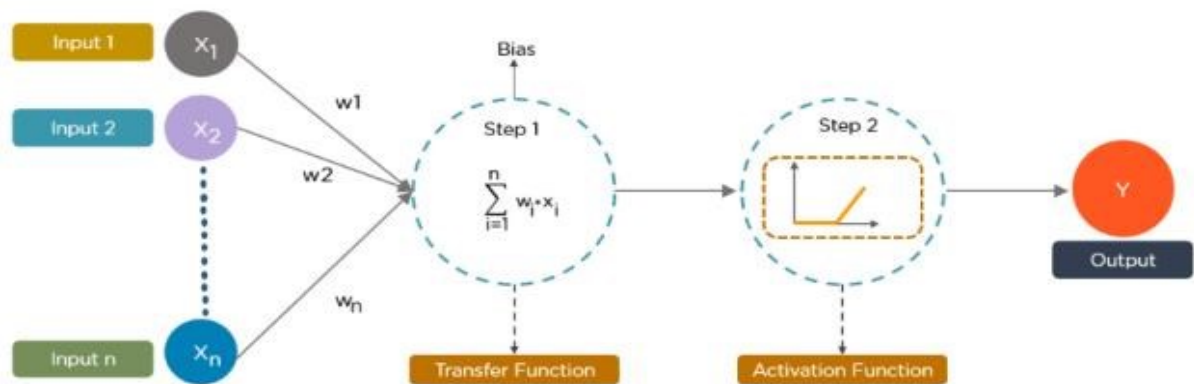


Figure 1. Three type of DNN

3. Algorithms in Deep Learning

In the field of deep learning, there exist various types of algorithms, including Convolutional Neural Networks (CNNs), Long Short Term Memory Networks (LSTMs), Recurrent Neural Networks (RNNs), Generative Adversarial Networks (GANs), Radial Basis Function Networks (RBFNs), Multilayer Perceptrons (MLPs), Self Organizing Maps (SOMs), Deep Belief Networks (DBNs),

Restricted Boltzmann Machines (RBMs), and Autoencoders. The Long Short-Term Memory Network (LSTM) is chosen to represent the algorithms of deep learning to be analyzed and introduced in this section [4].

LSTM has a chain-like structure in which four interacting layers communicate in a unique way. It learns and remembers long-term interdependencies because remembering past information for long periods of time is a default behavior, and therefore information can be retained for long periods of time. Based on this property, LSTM is very useful in time series forecasting. And it can be used to learn, process, and categorize continuous data because these networks can learn long-term dependencies between data time steps. In addition to time series prediction, LSTM is commonly used in speech recognition, sentiment analysis, language modeling, video analysis, music composition, and drug development. LSTM networks are well suited for classification, processing, and prediction based on time-series data, where there may be unknown time lags between important events in the time series [6].

RNNs find extensive applications in image captioning, time series analysis, natural language processing, handwriting recognition, and machine translation. One notable feature of RNNs is their ability to form directed loops in their connections, enabling the output of the LSTM to serve as input for the current stage and retain memory of previous inputs. This mechanism allows the output at time $t-1$ to influence the input at time t , and similarly, the output at time t to influence the input at time $t+1$. RNNs can handle inputs of varying lengths, as the computation takes into account historical information, and the model size remains constant regardless of the input size.

4. Learning process

4.1. Training

As a core component of the field of artificial intelligence, machine learning refers to the process by which a non-explicit computer program learns how to handle a task by learning from data experience to optimize its own algorithms. The process of machine learning is that a computer program starts from a certain or limited set of learning data (usually based on the assumption that each data sample is independent and identically distributed), selects a certain modeling method (assuming that the learning model belongs to a certain set of functions, also known as the hypothesis space), optimizes the processing of the metrics performance of the task by algorithmically updating the model's parameter values (experience), and ultimately learns a better model and uses the model to analyze and predict the data group to finally complete the task. Thus, there are four elements to a machine learning approach: model, data, learning objective, and optimization [5]. Learning a "good" model is the direct goal of machine learning. Simply put, a machine learning model is a function that learns the relationship between data features and labels, or the internal laws of data features. Among them, K-means can cluster different groups and categorize the dataset into K classes (Figure2). LSTM is used to solve nonlinear regression and time series problems.

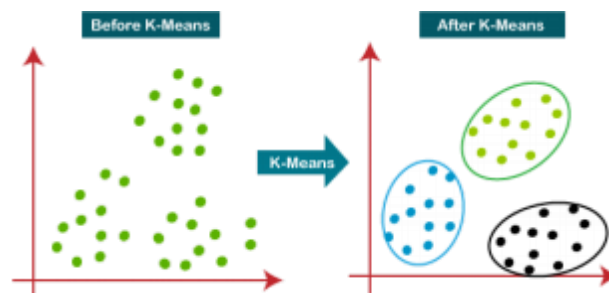


Figure 2. Categorizes the dataset by K-means

Neural networks acquire knowledge through a process called training, where they analyze instances consisting of known inputs and outcomes. During training, the network establishes probabilistic

connections between the inputs and outcomes, which are then stored within the network's data structure. When training a neural network using a specific instance, it is typical to calculate the discrepancy between the network's output (typically the predicted outcome) and the desired output, known as the target output. The disparity between the network's output and the desired output is referred to as the error. The neural network then modifies its weighted connections based on a learning rule, utilizing this error value. Through successive adjustments, the neural network gradually aligns its outputs with the target output. Once a satisfactory number of adjustments have been made, the training process can be concluded based on specific criteria. This type of system utilizes supervised learning, where it acquires the ability to perform a task by observing examples and typically does not necessitate the programming of task-specific rules. In image recognition, for instance, the system can learn to identify images featuring cats by examining manually labeled examples categorized as "cat" or "no cat." By leveraging the outcomes of this analysis, the system can subsequently identify cats in other images without explicitly programmed rules. The system does not know any information about the cat, e.g., hair, tail, whiskers, etc., prior to image recognition. During the recognition process, they automatically generate recognition features from the processed examples [6]. Deep learning algorithms rely on artificial neural networks (ANNs) that emulate the information processing mechanism of the human brain, enabling the algorithms to learn and improve on their own. Throughout the training process, these algorithms leverage unknown elements within the input distribution to extract meaningful features, categorize objects, and uncover valuable patterns in the data. Similar to training machines to learn autonomously, this iterative process occurs at various levels, with the algorithms constructing models to enhance their capabilities.

4.2. Used in real life

Modern GPUs have enabled single-layer networks in the 1960s and two- to three-layer networks in the 1980s to evolve into today's 10-, 15-, and even 50-layer networks. Currently, deep learning stands as the leading system across nearly all domains of AI research, demonstrating superior performance. The neural layout of the human brain is similar to the structure of a network, and neurons are the intersection of networks. Human cognitive patterns and ways of doing things are stored in connections between neurons that are called "neuronal connection weights". The weights are the connections of the network, and these connections are thick or thin, which means that they have different weights. Humans learning ability is to constantly change the value of the weights so as to change their own cognitive patterns and ways of doing things. Simply put, different people will have different perceptions of the same external thing. This is because the same initial signal becomes a final signal with a different emphasis after being amplified or reduced by neurons of different thicknesses (Figure 3) [7].

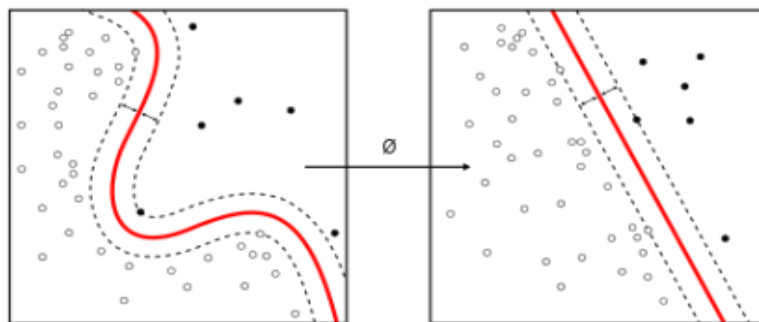


Figure 3.

5. Analysis

Neural networks have already had a positive impact on current technology, and more will be possible as they are optimized and enhanced for the sake of the technology.

5.1. Further development direction

5.1.1. Advancements in artificial intelligence (AI):

Modern AI systems are built around neural networks. They allow machines to make judgments, comprehend natural language, identify patterns, and even display creativity. Artificial intelligence (AI) systems will be better able to handle difficult tasks like advanced problem solving, creative content creation, and tailored suggestions as neural network topologies evolve [3].

5.1.2. Autonomous Systems:

The advancement of robots, drones, and autonomous vehicles depends on neural networks. These systems are able to observe their surroundings, make quick decisions, and navigate challenging circumstances thanks to them. Autonomous systems will becoming safer and more dependable as neural networks advance [5].

5.1.3. Healthcare Diagnostics and Treatment:

For quicker and more precise diagnosis, neural networks are being utilized to evaluate medical imagery such as X-rays and MRIs. By foreseeing possible drug interactions and identifying prospective candidates for new drugs, they can also help with drug discovery [4].

5.1.4. Natural Language Processing (NLP):

Neural networks have revolutionized NLP activities like sentiment analysis, language translation, and chatbots. We may anticipate more sophisticated language models in the future that can comprehend context, emotion, and nuance in human conversation [7].

5.1.5. Virtual and augmented reality:

Neural networks contribute to making virtual and augmented reality experiences more realistic and interactive. Within these immersive environments, they make gesture detection, facial expression tracking, and object recognition more precise.

Neural networks are used in finance and trade to forecast market trends, manage portfolios, and automate trading techniques. They examine a sizable amount of financial data to make wiser investing choices. Neural networks can help with climate modeling and environmental monitoring by processing massive information to forecast weather patterns, monitor natural disasters, and spot trends in climate change. Neural networks are also capable of analyzing a person's genetic information, medical history, and lifestyle to offer individualized therapy recommendations. Healthcare interventions might become more efficient and focused as a result [6].

5.2. Limitation

While machine learning, particularly neural networks, has significantly advanced technology and many other sectors, it's crucial to recognize that these methods still have difficulties and limitations.

Since neural networks learn from data, they may pick up biases from the training set if it is unrepresentative or prejudiced. Results from this may be unfair or discriminatory, particularly in fields like hiring, lending, and criminal justice. Not only but also, for effective training, neural networks frequently need a lot of high-quality labeled training data. Finding enough reliable training data can be difficult or expensive in many real-world situations. that likely to take a lot of processing time and power, as well as powerful GPUs, to train sophisticated neural network models. This may restrict the availability of these methods to academics and organizations lacking sufficient funding [8]. On the other side, Training complex neural network models can require substantial computational resources, including powerful GPUs and extensive training time. This can limit the accessibility of these techniques to researchers and organizations without adequate resources, might not be able to reason rationally or recognize context. When faced with situations that call for a thorough comprehension of the human context and broad knowledge, they are susceptible to making mistakes. That would lead to

neural networks struggling with learning new information while retaining previously learned knowledge (known as catastrophic forgetting). This hampers their ability to adapt to new situations over time. It's important to recognize these defects and challenges in order to address them and work toward creating more robust, ethical, and effective machine learning systems. Researchers and practitioners are actively working on developing techniques to mitigate these issues and improve the overall reliability and usefulness of neural networks and machine learning methods.

6. Conclusion

Neural networks and different fields have been applied in collaboration, and their iterative updates have led to changes in technology within different fields. This paper illustrates and summarizes the role of neural networks in facilitating artificial intelligence, enabling autonomous systems, enhancing medical diagnostics and revolutionizing natural language processing by exploring their applications. However neural networks that are upgraded based on large amounts of data computation and training can be hampered by the lack of relevant data, or the lack of sufficient data.

Although this paper analyzes the application of neural networks in different industries, this paper does not empirically analyze and test the data in the identified areas, so the content is obtained based on the reading and organization of literature. Subsequently, the authors will enhance the experimental capabilities related to neural network applications to further optimize this article.

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