An Overview of Deep Learning Algorithms and its Applications in Health Care

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Abstract- The applications of Machine Learning techniques like deep learning have been increased in the last few years in different areas like fraud detection, health care, manufacturing etc. In order to extract hidden patterns and other important information from the vast amount of data traditional analytics cannot find in a reasonable amount of time. ML algorithms offer effective and efficient data analysis models. Particularly, it has been demonstrated that Deep Neural Network (DNN) models hold promise for pattern recognition in healthcare, manufacturing and in many other systems. This paper is providing an overview of the different types of deep learning algorithms. It is also briefing about the applications of deep learning in the different health care domains.

Indexed Terms- Artificial neural network, convolutional neural network, deep q networks, recurrent neural network

I. INTRODUCTION

After decades of study and development, deep learning—which started out as artificial neural networks (ANNs)—has become significantly more efficient than previous machine learning methods [1]. When neural networks were first being developed, scientists wanted to build a system that would replicate the way the human brain worked. In 1943, McCulloc and Pitts tried to explain how neurons in the brain could produce such complex patterns [2]. As a part of their work the development of artificial neural networks came into existence through their MCP (McCulloch Pitts neurone) model. Instead of learning, threshold logic was used to model human cognitive processes. Since then, deep learning has advanced gradually but steadily, reaching a number of noteworthy milestones along the way [3].

Research on the evolution of neural networks and artificial intelligence paused when MIT professors Minsky and Papert demonstrated the limitations and drawbacks of the perceptron in 1969 [4]. When Werbos developed the backpropagation method in 1974, the impasse was broken [5]. In terms of neural network development, it is seen as a major turning point. The "Neocognitron" is considered the precursor of convolutional neural networks and was first presented by Fukushima [6] in 1980. Next were the recurrent neural network (created by Jordan in 1986 [7]) and the Boltzmann machine (created by Hintonetal in 1985 [1]). Yan LeCun first proposed the use of backpropagation in convolutional neural networks for document processing in 1998 [8]. Since Hinton first proposed the idea of deep belief networks (DBNs) in 2006, deep learning has advanced significantly [9,10]. As a part of their proposal pre-training and fine-tuning were the two stages of the plan that are involved in these. As compared to other approaches, this technique enables researchers to train neural networks more appropriately.

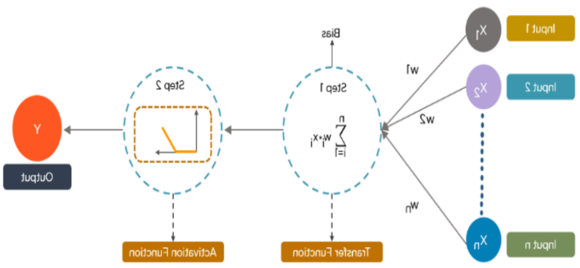
II. OVERVIEW OF DEEP LEARNING

One machine learning method that trains computers and other devices to work logically is called deep learning in which the structure of the human brain served as its inspiration. In order to process vast volume of data and to carry out complex calculations artificial neural networks are used in deep learning. Examples are used in deep learning algorithms to teach the machines. It is frequently used in sectors including advertising, eCommerce, healthcare, and entertainment.

A. Neural network

A branch of machine learning is "deep learning". It processes and analyzes data using artificial neural networks. The foundation of deep learning technology comprises of Neural networks, which are composed of layers of interconnected nodes, or neurons Through coordinated and adaptive data processing, these nodes continuously improve and learn from their mistakes. Hence, neural networks are made up of artificial neurons, or nodes, that resemble the structure of the human brain. Three layers of these nodes are stacked adjacent to one

another as:
Output layer; Input layer; Hidden layer/s



The inputs of each node is the information obtained from data. The node applies a bias, multiplies the inputs by random weights, and computes them. Activation functions which are nonlinear functions are used to select the neurone to fire.

III. DEEP LEARNING ALGORITHMS

Deep learning techniques rely on artificial neural networks (ANNs). ANN functions in the same way as the human brain processes information. During training, algorithms are used for unknown components in the input distribution to group objects, extract features, and identify useful patterns in the data. A variety of algorithms are used in deep learning models and also no network is considered to be perfect for a certain algorithm. Some algorithms are better suited to perform specific tasks. In order to obtain the best algorithms, one needs to have a suitable understanding of all the major ones.

The popularity of deep learning has been seen in scientific computing and its methods which are used to deal complex problems. Different types of neural networks are used for all deep learning algorithms in order to perform a specific task.

IV. POPULAR DEEP LEARNING ALGORITHMS

This section discusses the different deep learning algorithm which are commonly used.

A. Convolutional Neural Network (CNN)
CNNs are deep learning systems that process various structured grid data, including images. In tasks involving object identification, image classification, and facial recognition, they have demonstrated proficiency.

Functioning of CNN
- Convolutional Layer: Applying a collection of filters (kernels) this layer manipulates the input image and creates a feature map. This helps in the detection of numerous features, including patterns, textures, and edges.
- Pooling Layer: This layer keeps the most important information while reducing the feature maps' dimensionality. It uses average pooling and maximum pooling.
- Fully Connected Layer: The output is flattened and fed into one or more fully connected (dense) layers following a number of convolutional and pooling layers. A final classification or prediction is made by the output layer.

B. Recurrent Neural Network (RNN)
RNNs are intended to identify patterns of data sequences like time series and natural language. They keep track of information about past inputs in a hidden state.

Functioning of RNN
- Hidden State: The current input and the previous hidden state are used to update the hidden state at each time step. This enables the network to keep track of previous inputs.
- Output: At every time step, the hidden state produces an output. In order to reduce the prediction error, the network is trained with Back Propagation Through Time (BPTT).

C. Long Short-Term Memory Networks (LSTMs)
Long-term dependencies can be learned by LSTMs, a unique type of RNN. They are better at tasks like time series prediction and speech recognition because they are made to avoid the long-term dependency issue.

Functioning of LSTM
- Cell State: LSTMs can carry information across numerous steps and have a cell state that spans the entire sequence.
- Gates: The information flow is managed by three gates: input, forget, and output.
- Input Gate: Selects the data from the current input that needs to be changed in the cell state.
- Forget Gate: Selects which data from the cell state should be removed.
- Output Gate: Regulates what data, depending on the cell state, should be output.

D. Generative Adversarial Networks (GANs)

- By training two neural networks in a competitive environment, GANs produce realistic data. They have been used to produce lifelike audio, video, and images.

Functioning of GAN

- Generator Network: Uses random noise to produce fictitious data.
- Discriminator Network: Assesses data authenticity, differentiating between authentic and fraudulent data.
- Training Procedure: Training is done concurrently for the discriminator and generator. The discriminator seeks to improve its ability to identify phony data, while the generator attempts to trick the discriminator by creating better fake data. The generator produces more realistic data as a result of this adversarial process.

E. Transformer Networks (TN)

The foundation of many contemporary NLP models is transformers. They use self-attention to process input data, which enables parallelization and better management of long-range dependencies.

Functioning of TN

Self-Attention Mechanism: This mechanism allows the model to weigh the significance of various words in a sentence differently by calculating the importance of each input component in relation to every other component.

Since sequence order is not automatically captured by self-attention, positional encoding adds information about the words' positions in the sequence.

An encoder processes the input sequence, while a decoder creates the output sequence. This architecture is known as encoder-decoder. Each is made up of several feed-forward and self-attentional network layers.

F. Autoencoders

For tasks like data compression, denoising, and feature learning, autoencoders are unsupervised learning models. They acquire the ability to decode data back to its original form after encoding it into a lower-dimensional representation.

Functioning of Autoencoders

• Encoder: Converts the input data into a representation in lower-dimensional latent space. The compressed form of the input data is represented by the latent space.
• Decoder: Reconstructs the latent representation of the input data.
• Training: The network reduces the variation between the input and the output that is reconstructed.

G. Deep Belief Networks (DBNs)

Multiple layers of stochastic, latent variables make up DBNs, which are generative models. They are employed in dimensionality reduction and feature extraction.

Functioning of DBN

• Layer-by-Layer Training: DBNs receive training in a layer-by-layer, greedy manner. Every layer learns to reconstruct its input by being trained as a Restricted Boltzmann Machine (RBM).
• Fine-Tuning: Backpropagation can be used to fine-tune the entire network for particular tasks after the layers have been pretrained.

H. Deep Q-Networks (DQNs)

To manage environments with high-dimensional state spaces, DQNs integrate deep learning with the reinforcement learning algorithm Q-learning. They have been effectively used for tasks like controlling robots and playing video games.

Functioning of DQN

• Q-Learning: Shows the value of performing an action in a specific state using a Q-table. A deep neural network, which approximates the Q-values for various actions given a state, takes the place of the Q-table.
• Experience Replay: This technique improves training stability by storing previous experiences in a replay buffer and sampling from it to break the correlation between successive experiences.
• Target Network: To stabilize training, a different network with postponed updates.

I. Variational Autoencoders (VAEs)

Variational inference is used by VAEs, which are generative models, to produce new data points that are comparable to the training set. They are employed in anomaly detection and generative tasks.

Functioning of VAE

• Encoder: Converts input data into a latent space probability distribution.
Latent Space Sampling: This method adds variability to the generated data by taking samples from the latent space distribution.
Data is generated from the sampled latent representation by the decoder.
• Training: This technique encourages the latent space to adhere to a conventional normal distribution by combining reconstruction loss with a regularization term.

J. Graph Neural Networks (GNNs)

Neural networks are extended to graph-structured data by GNNs. They are employed in recommendation systems, molecular structure analysis, and social network analysis.

Functioning of GNN

• In graph representation, entities are represented by nodes, and relationships between entities are represented by edges.
• Message Passing: To update their representations, nodes compile data from their neighbors. This procedure can be carried out multiple times.
• Readout Function: For tasks like classification or regression, a readout function aggregates node representations following message passing to create a graph-level representation.

V. APPLICATIONS OF DEEP LEARNING IN HEALTH CARE

Deep learning has revolutionized a number of industries, including healthcare. By examining vast amounts of data and identifying patterns that are often imperceptible to the human eye, deep learning is transforming the way medical professionals diagnose conditions, predict patient outcomes and develop customized treatment. It has several uses in the medical field. It is utilized in medical imaging and diagnostics for lung disease diagnosis, breast cancer detection, and other purposes. Risk management and predictive analytics are used in diabetes care, hospital readmission risk, and many other areas. Deep learning is used in personalized medicine for things like drug response prediction and genomic analysis of cancer treatment. Information extraction from unstructured EHR data and clinical documentation automation both heavily rely on natural language processing.

Regarding Rehabilitation and Assistive Devices, ReWalk Robotics is using deep learning to develop exoskeletons that adapt to the movements of paraplegic patients and provide tailored support, allowing them to walk. The EksoGT exoskeleton from Ekso Bionics increases mobility through personalized therapy using deep learning to aid in the recovery of stroke and spinal cord injury patients.

When it comes to Rehabilitation and Assistive Devices then Deep learning is being used by ReWalk Robotics to create exoskeletons that enable paraplegic patients to walk by adjusting to their movements and offering customized support. Through individualized therapy, the EksoGT exoskeleton from Ekso Bionics uses deep learning to help stroke and spinal cord injury patients recover by increasing mobility.

CONCLUSION

The origin of deep learning with different popular algorithms have been discussed in this paper. A brief introduction of the algorithms along with their functioning have been presented. The paper also highlighted about the recent applications of deep learning in different healthcare domain. This includes the different examples of medical imaging, risk management, predictive analytics, rehabilitation and assistive devices where deep learning has been used to improve the medical facilities to great extent.

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