



APPLICATIONS OF NEURAL NETWORKS AND DEEP LEARNING

Sharvari Dhuri

Rustomjee Cambridge International School
and Junior College
dhurishar@gmail.com

Abstract

This research paper briefly summarises what Neural Networks and Deep Learning is and how its applications are improving today's life. I have taken help of information available in various research papers on different websites. This spans from theory behind the Neural Network, Advantages, disadvantages to the uses of Deep Learning.

KEYWORDS

Artificial Intelligence: Artificial intelligence (AI) refers to the simulation of human intelligence in machines that are programmed to think like humans and mimic their actions.

Machine Learning: Machine learning is a branch of artificial intelligence (AI) and computer science which focuses on the use of data and algorithms to imitate the way that humans learn, gradually improving its accuracy.

Neuron: Neurons are the fundamental units of the brain and nervous system, the cells responsible for receiving sensory input from the external world, for sending motor commands to our muscles, and for transforming and relaying the electrical signals at every step in between

Normalisation: Normalization is an approach which is applied during the preparation of data in order to change the values of numeric columns in a dataset to use a common scale when the features in the data have different ranges.

Autoencoder: An autoencoder is a type of artificial neural network used to learn efficient codings of unlabelled data

INTRODUCTION

We keep hearing words like Neural Network and Deep Learning from computer scientists and software professionals. What do they really mean? In what context they are used? These were some of the questions I had and it actually created interest in my mind due to its similarities with terminologies used in reference of Brain taught in Biology. Is it similar or is it totally different? If it is similar in what way it is similar and if different, how it is different?

So, this paper is the follow up on my enthusiasm to understand these concepts and understand why these concepts are being discussed by these professionals in today's world.

THEORY

The formula given above is to determine the output at every node in a neural network.

$$Y = \Sigma (\text{input} * \text{weights}) + \text{bias}$$

WHAT IS DEEP LEARNING AND NEURAL NETWORKS?

Deep Learning (DL) is a part of machine learning where in there is a system of artificial neural networks with a large number of hidden artificial neural network layers. The artificial neural networks try to simulate the functioning of the human brain. This allows the artificial neural networks to “learn” similar to human brain learning. If the artificial neural networks can process information on their own then why would we use Deep Learning? This is because an artificial neural network is a single layer which can make approximate predictions, however, if we want accuracy in predictions, we would need to use hidden layers which are present in Deep Learning.

HOW DOES IT WORK?

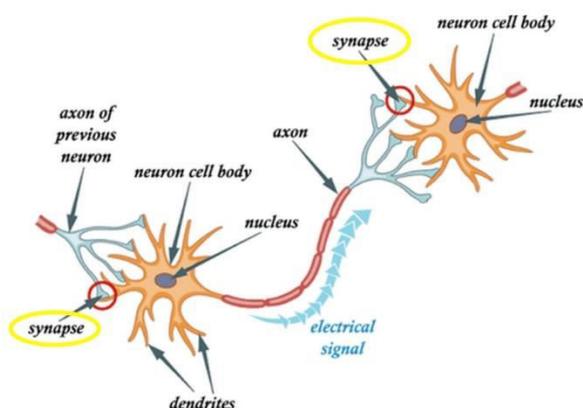


Fig.1 Two Neurons Connected

Artificial Neural Networks try to simulate the function of brains therefore they will have similar structure to neurons, which are present in the human brain, connected to each other. At the one end of a Neuron there are many dendrites which are connected to the axon of another Neuron (as shown in Fig.1). The dendrites receive signals from the axon. The signal travels through the neuron and passes onto another neuron.

Such Artificial neural network can be created in software or hardware of computer. The network can be represented as shown in **Fig.2**. The circles are nodes which act as artificial neurons. The Neural Network mentioned above can be grouped into three different layers:

- I. Input Layer
- II. Hidden Layer
- III. Output Layer

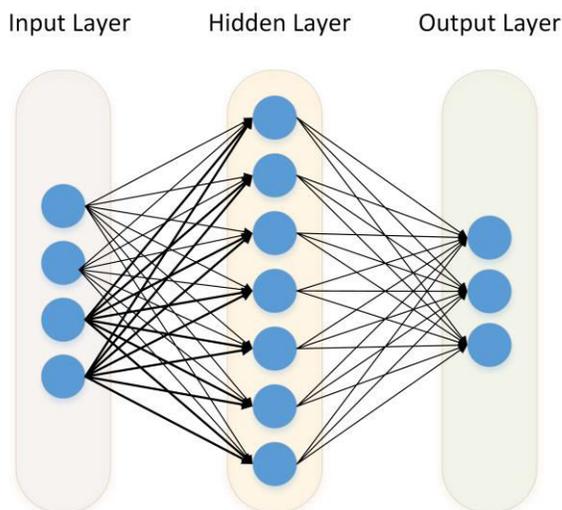


Fig.2 Neural Network present in DL



The Input layer receives data. The Output layer provides the output. Between these two layers, there is hidden layer. The hidden layer can be made up of one layer or multiple layers. The hidden layer does mathematical calculations on the inputs that we have provided in Input Layer. There are two steps in which all neural networks work and those are called forward propagation and backward propagation. Forward propagation is where we calculate the output by initializing parameters and using functions starting from Input Layer. Such functions and parameters are applied subsequently at every Node. When we get the output, it is compared to the expected output. If the output has an error in it so that it is not as per our expectations, we try to minimize this error by updating the parameters. This updating of parameters is called backward propagation.

To explain in detail how forward propagation works we will consider a neural network with two hidden layers. Then let the inputs be x_1 and x_2 . To calculate the output at every node we are going to use the equation mentioned under 'Theory' as given below.

$$Y = \Sigma (\text{input} * \text{weights}) + \text{bias}$$

For this equation to work, we will need parameters weight and bias and function 'Activation function'. Weights are the co-efficient of the equation which you are trying to resolve. Bias is a constant value which is used to shift the result of the 'Activation function' towards the positive or negative side. The Activation function is a mathematical function which normalizes the output. Thus, let the weights be w_1 and w_2 . So, equation would become:

$$Y = \text{activation function}(x_1 w_1 + x_2 w_2 + \text{bias})$$

This is how the final output 'Y' is achieved. The Neural Network that was explained here is a basic one. There are so many other types of neural networks to solve different types of problems. The Neural Networks listed below are few of the top Networks.

Types of Neural Networks:

1. Feed-Forward Neural Networks
2. Radial Basis Function Neural Network
3. Multilayer Perceptron
4. Convolutional Neural Network
5. Recurrent Neural Network
6. Modular Neural Network
- 7.

ADVANTAGES OF NEURAL NETWORKS

- In this digital age the amount of data found on the internet is enormous and disorganized. If a normal Machine learning algorithm is used you would first need to organize the data. However, this is where Deep learning algorithms are at its best. Data of different formats can be used to train Deep learning algorithms.
- After training the deep learning algorithms perfectly, the algorithm can perform complex tasks in a matter of minutes with accuracy and precision.
- Deep learnings also can identify the features of a dataset without the researchers' help and therefore saves a lot of time and cost for the researchers.
- It also eliminates the need to label the data because the Deep Learning algorithm does not need any guidelines.



An International Multidisciplinary Research e-Journal

- Deep learning algorithm can detect error by itself which is very difficult to identify for humans.
- Deep learning algorithm's structure can be altered to a specific problem.

DISADVANTAGES OF NEURAL NETWORKS

- Deep learning algorithms require a large dataset to give accurate results. So, if sufficiently large data is not provided the algorithm may fail.
- If the deep learning algorithm has a lot hidden layers in it, it will require processors of high power which increases the cost.
- The Deep learning algorithm can be prone to bias which exist in input data, such as racial bias.
- If there are a lot of layers, the training process will consume lot of time.
- There is no fixed theory on how you can structure a deep learning algorithm so the researcher has to have understanding of the topology and the parameters.

APPLICATIONS

There is a difference between machine learning and deep learning where machine learning is often just used for specific tasks and deep learning, on the other hand, is helping solve the most complex problems of the human race. Some of the applications are as follows:

- **Healthcare**
According to NVIDIA, the multinational company designing graphics processing units, "From medical imaging to analysing genomes to discovering new drugs, the entire healthcare industry is in a state of transformation and GPU computing is at the heart. GPU-accelerated applications and systems are delivering new efficiencies and possibilities, empowering physicians, clinicians, and researchers passionate about improving the lives of others to do their best work."
Thus, there can be several deep learning projects like helping early, accurate and speedy diagnosis of life-threatening diseases, pathology results and treatment course standardization, understanding genetics to predict future risk of diseases and negative health episodes in the Healthcare domain. Readmissions in health care facility is a huge problem for the healthcare sector as it costs tens of millions of dollars in cost. But with the use of deep learning and neural networks, healthcare giants are reducing health risks associated with readmissions while bringing down the overall costs. Deep Learning is also being excessively used in clinical researches by regulatory agencies to find cures to untreatable diseases. However, physicians' disbelief and lack of a humongous dataset are still creating challenges to the use of deep learning in medicine.
- **Stock Analysis**
Quantitative Equity Analysts are getting more benefits, to find the trends for a particular stock whether it will be bullish or bearish and they can use many more factors like number of transactions made, number of buyers, number of sellers, previous day closing balance, etc. when training the deep learning layers. Qualitative Equity Analysts use economic factors like return on equity, P/E ratio, Return on Asset, Dividend, Return on Capital Employed, Profit per Employee, Total Cash, etc. when training the deep learning layers.



- **Fraud Detection**
Another area where Deep Learning is useful is the banking and financial sector that is suffering with the task of fraud detection with money transactions going digital. Autoencoders in free and open-source software libraries like Keras and TensorFlow are being developed to detect credit card frauds saving billions of dollars of cost in recovery and insurance for financial institutions. Fraud detection and prevention are carried on based on identifying patterns in customer transactions and credit scores, identifying anomalous behaviour and outliers. Machine learning is widely used in fraud detection however its downside is that it requires human deliberation. This is where deep learning is trying minimize human deliberation by scaling efforts.
- **Image Recognition**
Can you imagine yourself going through a plethora of old images taking you down the nostalgia lane? You decide to get a few of them framed but first, you would like to sort them out. The maximum you could do was to sort them out based on dates but downloaded images lack that metadata sometimes. Due to Deep Learning now images can be sorted based on locations detected in photographs, faces, a combination of people, or according to events, dates, etc. Searching for a particular photo from a library (e.g., dataset as large as Google's picture library) requires high level visual recognition systems consisting of several layers from basic to advanced, to recognize elements. Large-scale image Visual recognition through deep neural networks is increasing growth in this segment of digital media management by using convolutional neural networks.
- **News Analysis**
Now there is a way to filter out all the bad and ugly news from your news feed. Extensive use of deep learning in news aggregation is planned to customize news as per readers. While this may not seem new, recent levels of sophistication to define reader personas are being met to filter out news as per geographical, social, economic parameters along with the individual preferences of a reader. Further, detection of Fraud news is an important asset in today's world where the internet has become the primary source of all genuine and fake information. It is very difficult to distinguish fake news as bots replicate it across various channels automatically. The Cambridge Analytica is the best example of how fake news, personal information, and statistics can influence reader's perception (Bhartiya Janta Party vs Indian National Congress), elections (e.g., Donald Trump Digital Campaigns), and exploit personal data (compromising Facebook data for approximately 87 million people). Deep Learning helps develop classifiers that can detect fake or biased news and remove it from your feed and warn you of possible privacy breaches. Training and validating a deep learning neural network for news detection is really hard as the data is filled with opinions and no one can ever decide if the news is neutral or biased.
- **Self-driving Cars**
Deep Learning is also spreading fast to bring life to autonomous driving. To train the machines to learn and then test the results in a safe environment, a million sets of data are fed to a system to build a model. The Artificial Intelligence Labs for Uber at Pittsburg is not only working on making driverless cars popular but also integrating several smart



features such as food delivery options with the use of driverless cars. The major concern for autonomous car developers is handling unprecedented scenarios. A regular cycle of testing and implementation typical to deep learning algorithms is ensuring safe driving with more and more exposure to millions of scenarios. Data from cameras, sensors, geo-mapping is helping to create concise and sophisticated models to navigate through traffic, identify paths, signage, pedestrian-only routes, and real-time elements like traffic volume and road blockages. MIT is currently trying to develop a new system that will allow autonomous cars to navigate without a map to handle roads beyond the small number of roads that tech companies have already mapped. However, this is challenging because it is much harder to reach the same accuracy and reliability as with detailed maps.

- Natural Language Processing

Understanding the complexities associated with language whether it is syntax, semantics, tonal nuances, expressions, or even sarcasm, is one of the difficult tasks for humans to learn. Regular training since birth and continuous exposure to different social settings help humans develop appropriate responses and a personalized form of expression to every scenario. Natural Language Processing (NLP) through Deep Learning is trying to achieve this by training machines to learn linguistic details and frame appropriate responses. The subsets in NLP where Deep Learning is gaining momentum are answering questions, language modelling, classifying text, twitter analysis. Before Machine Learning algorithms were used to build time-consuming complex models but now distributed representations, convolutional neural networks, recurrent and recursive neural networks, reinforcement learning, and memory augmenting strategies are helping achieve greater growth in NLP.

- Virtual Assistants

The most recognised application of deep learning is virtual assistants such as Alexa. The Virtual assistants learn more about your voice and accent when you interact with them. Virtual assistants use deep learning to know more about their subjects ranging from your most visited spots to your dine-out preferences to your favourite songs. They *learn* to understand your commands by evaluating natural human language to execute them. Another capability virtual assistants are showing is to translate your speech to text, make notes for you, and book appointments. Virtual assistants can do everything from running errands to auto-responding to your specific calls to coordinating tasks between you and your team members. Using deep learning applications such as text generation and document summarizations, virtual assistants can assist you in creating or sending appropriate email copy as well.

- Language Translations

One of the fascinating applications of Deep Learning includes the Image – Language translations. With the Google Translate app we can in real time automatically translate photographic images with text into language of your choice. All one needs to do is to hold the camera on top of the object and your phone runs a deep learning network to read the image, Optical Character Recognition takes place (i.e., convert it to text) and then translate it into a text in the preferred language. This is an extremely useful application in the current world where many languages are spoken from region to region and country to



country. With this application, languages will gradually stop being a barrier, allowing universal human communication.

- Pixel Restoration

In chemical photography, since the original film is analogue, the zooming is limited by the molecules on the photo film. Since molecules are very tiny, one can zoom deeply in a good quality chemical photo film. However, now, digital photography has replaced chemical photography due to other advantages. The side effect of this change is that zooming in is now limited by the digital pixels of original digital image. Deep learning is able to overcome this challenge by creating additional virtual pixels when one tries to zoom. The advantage of these deep learning based is that the zoom seems smooth to human eyes, while providing zoomed details. Companies like Google are working in this area.

- Demographic Predictions

Deep learning is able to identify makes & models of the cars it sees. At the same time, deep learning also has created correlation between types of cars owned by people of various income strata of society. Combining the two, companies like Google are able to make predictions of income levels of a particular location based on cars seen in that location.

- Mass customisation and real time analytics in Entertainment

Wimbledon 2018 used IBM Watson to analyse player's emotions and expressions through hundreds of hours of footage to auto-generate highlights for telecast. This saved a lot of effort and cost. Due to Deep Learning, they were able to factor in audience response and match or player popularity to come up with a more accurate model, otherwise it would just have highlights of the most expressive or aggressive players.

Netflix and Amazon are enhancing their deep learning capabilities to provide a personalized experience so that the viewers are recommended entertainment shows of their liking. To generate insights based on performance and popularity, VEVO has been using deep learning to create the advanced data services for not only personalized experiences for its users and subscribers, but also artists, companies, record labels, and internal business groups. Deep video analysis can save hours of manual effort required for audio/video sync and its testing, transcriptions, and tagging. Content editing and auto-content creation are now possible due to Deep Learning. Deep Learning AI is also bringing new revolution in the filmmaking process as cameras learn to study human body language to imbibe in virtual characters.

- Detecting Developmental delay in Children

Children suffering from Speech disorders, autism, and developmental disorders can deny a good quality of life to them due to any of these problems. An early diagnosis and treatment of differently-abled children can allow them live a life without any problems in physical, mental, and emotional health. Therefore, one of the noblest applications of deep learning is in the early detection and course-correction of these problems associated with infants and children. Researchers at the Computer Science and Artificial Intelligence Laboratory at MIT and Massachusetts General Hospital's Institute of Health Professions have developed a computer system that can identify language and speech disorders even



An International Multidisciplinary Research e-Journal

before kindergarten when most of these cases traditionally start emerging. In this deep learning, disorders can be detected when combined with cofactors such as low birth weight, age, etc.

CONCLUSION

We humans have been using electronic computers for last seventy years now. They have had given us great benefits by automating Yes/no or 0/1 rules. Now, with deep learning, computers can help us solve problems which do not have clear cut Yes/no rules, for example face recognition has no set of yes/no rules that can be implemented. But deep learning can help us solve these types of problems with confidence and low cost. Human welfare will definitely improve significantly if we implement deep learning responsibly.

A project using deep learning is to determine if a person is economically challenged based on the photographs of the condition of their house, so that the banks can identify how much loan to give to a person. I have done similar project in grade XI using machine learning and by manually tagging images of houses to estimated incomes of homeowners. This project can be expanded into deep learning so that society can benefit from it.

REFERNCES

Book

S.Langfield and D.Duddell, Artificial Intelligence in Computer Science for Cambridge International AS and A Level, Cambridge, United Kingdom, Cambridge University Press, 2019, ch. 22, pp. 406-407.

Websites

- 1) IBM Cloud Education “Deep Learning” ibm.com
<https://www.ibm.com/cloud/learn/deep-learning> (Accessed May. 23, 2021)
- 2) R.Raicea “Want to know how Deep Learning works? Here’s a quick guide for everyone.” freecodecamp.org



- <https://www.freecodecamp.org/news/want-to-know-how-deep-learning-works-heres-a-quick-guide-for-everyone-1aedeca88076/#:~:text=%20In%20summary%20E2%80%A6%20%201%20Deep%20Learning%20uses,set%20and%20comparing%20the%20outputs%20will...%20More%20>
(Accessed May. 29, 2021)
- 3) P. Shinde “Forward and Backward propagation” inblog.in
<https://inblog.in/Forward-and-back-propagation-Be2cOEcnKL> (Accessed June 17, 2021)
- 4) F. Malik “Neural Networks Bias and Weights” medium.com
<https://medium.com/fintechexplained/neural-networks-bias-and-weights-10b53e6285da>
(Accessed June. 17, 2021)
- 5) A. Ghoshal “Types of Neural Networks” educba.com
<https://www.educba.com/types-of-neural-networks/> (Accessed June. 30, 2021)
- 6) H. Ali Khan “Advantages and Disadvantages of Deep Learning” newsmaritime.com
<https://www.newsmaritime.com/2021/advantages-disadvantages-deep-learning/> (Accessed June. 30, 2021)
- 7) P. P. Damkar “Deep Learning” educba.com
<https://www.educba.com/deep-learning/> (Accessed June. 30, 2021)
- 8) M. Chatterjee “Top 20 Applications of Deep Learning in 2021 Across Industries” mygreatlearning.com
<https://www.mygreatlearning.com/blog/deep-learning-applications/#:~:text=Top%20Applications%20of%20Deep%20Learning%20Across%20Industries.%201.Detection.%203%203.%20Natural%20Language%20Processing%20%28NLP%29%20> (Accessed July. 7, 2021)
- 9) Dr A. Woodruff “What is a neuron” qbi.uq.edu.au
<https://qbi.uq.edu.au/brain/brain-anatomy/what-neuron> (Accessed July. 19, 2021)
- 10) A. Choudhury “Understanding Normalisation Methods in Deep Learning” analyticsindiamag.com
<https://analyticsindiamag.com/understanding-normalization-methods-in-deep-learning/#:~:text=Normalization%20is%20an%20approach%20which%20is%20applied%20during,which%20can%20be%20used%20in%20deep%20learning%20models>
(Accessed July. 19, 2021)
- 11) J. Frankenfield “Artificial Intelligence” investopedia.com
<https://www.investopedia.com/terms/a/artificial-intelligence-ai.asp> (Accessed July. 19, 2021)
- 12) IBM Cloud Education “Machine Learning” ibm.com
<https://www.ibm.com/cloud/learn/machine-learning> (Accessed July. 19, 2021)
- Figure*
Fig.1 <https://www.brains-explained.com/how-our-brains-learn/> (Accessed May. 29, 2021)



Indian Scholar

An International Multidisciplinary Research e-Journal



Fig.2 <http://www.marktorr.com/deep-learning/> (Accessed May. 29, 2021)