Neural Network Principles and its Application

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Abstract

Neural networks which also known as artificial neural networks is generally a computing dependent technique that formed and designed to create a simulation to the real brain of a human to be used as a problem solving method.

Artificial neural networks gain their abilities by the method of training or learning, each method have a certain input and output which called results too, this method of learning works to create forming probability-weighted associations among both of input and the result which stored and saved across the net specifically among its data structure, any training process is depending on identifying the net difference between processed output which is usually a prediction and the real targeted output which occurs as an error, then a series of adjustments achieved to gain a proper learning result, this process called supervised learning.

Artificial neural networks have found and proved itself in many applications in a variety of fields due to their capacity to recreate and simulate nonlinear phenomena. System identification and control (process control, vehicle control, quantum chemistry, trajectory prediction, and natural resource management. Etc.) In addition to face recognition which proved to be very effective.

Neural network was proved to be a very promising technique in many fields due to its accuracy and problem solving properties.

Keywords

Artificial, Neural, Networks, Supervised, Recognition, Stock, Unsupervised.

Introduction

A normal biological neural network is consist of a collection and group of functionally or chemically similar neurons. Each single neuron usually linked to a nearly large number of other units of neurons, the network's total number of connections and neurons is quite large.

Synapses are produced when axons link to dendrites, however dendrodendritic synapses and other connections are also conceivable. Other types of signaling emerge from neurotransmitter diffusion in addition to electrical transmission (Hahn, 2008).

On the other side, the neural network (NN) is known to be a huge parallel pattern distributed processor that consist of basic units in which have a natural ability and proclivity for storing and making connection accessible experience information, it is generally a designed computing technique that works to stimulate the brain in problem solving, human brain and neural network are both similar in that they learn how analyze input and solve problems through training. Neural network can also be called stimulated neural network (SNNs) and artificial neural network (ANNs) (Abe, 1997).

Neural network nowadays has been implemented in several applications such as robotics, human face recognition, medical applications, voice recognition, economics, and manufacturing.

The Architecture of Neural Network System

Human brain is mainly made up of 10^{11} computing units known as neurons that works together in parallel, in addition to exchange the information among their synapsis which are connectors units, these neurons mainly sums up all information that comes to them, if the result is greater than the given action potential, they will be sent a pulse directly via axon to the next phase (Sturges, 2013).

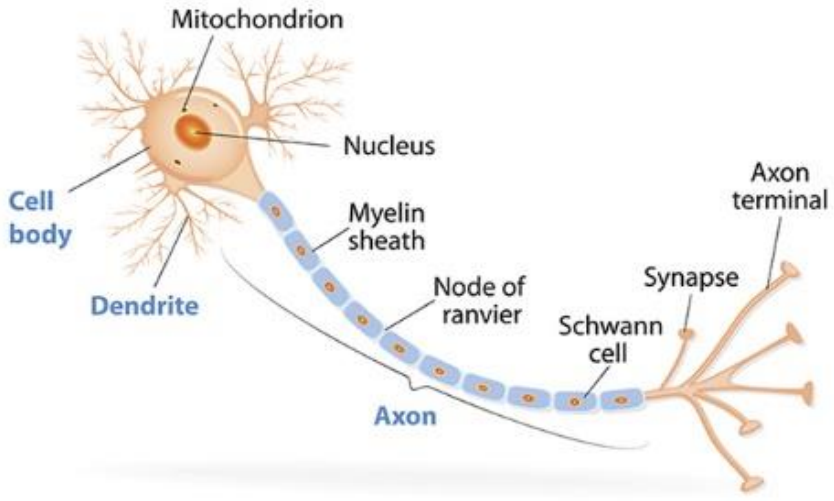

Figure 1 The anatomy of human neurons

As in human brain, also artificial neural network composed of simple and small units but they are computing units which called (Artificial Neuron), each single unit is linked to the other unit by weight connectors, after that, those units use squashing function to calculate the weighted sum of the coming inputs and find out the output (Farizawani, Puteh, Marina, & Rivaie, 2020).

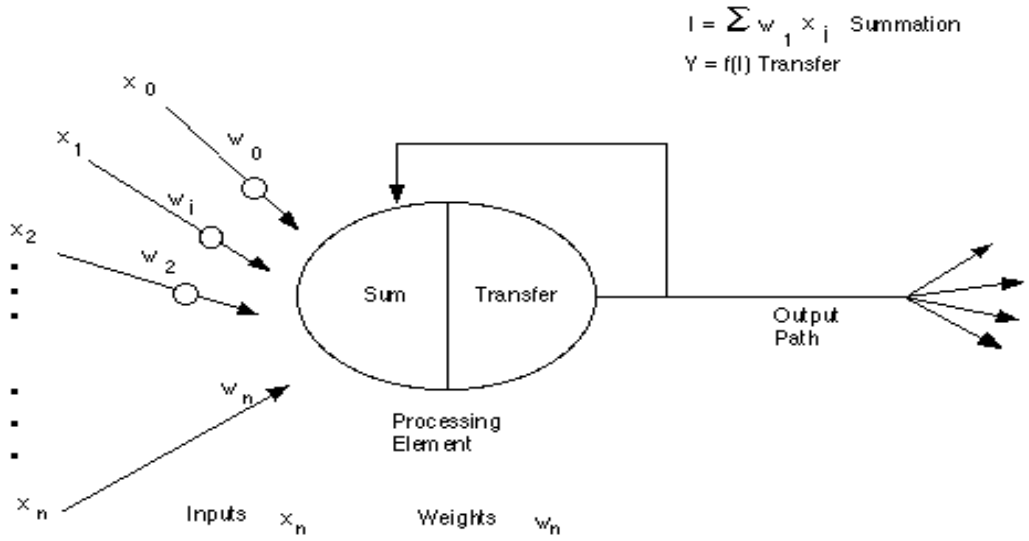

Figure 2 A basic artificial neuron

The larger the weight of the artificial neuron, is the greater the input amplified by an artificial neuron. The signal is suppressed by the negative weight, which can also be negative. The calculation of the neuron will alter depending on the weights (Özturan*, Bozanta, Basarir-Ozel, Akar, & Coşkun, 2015).

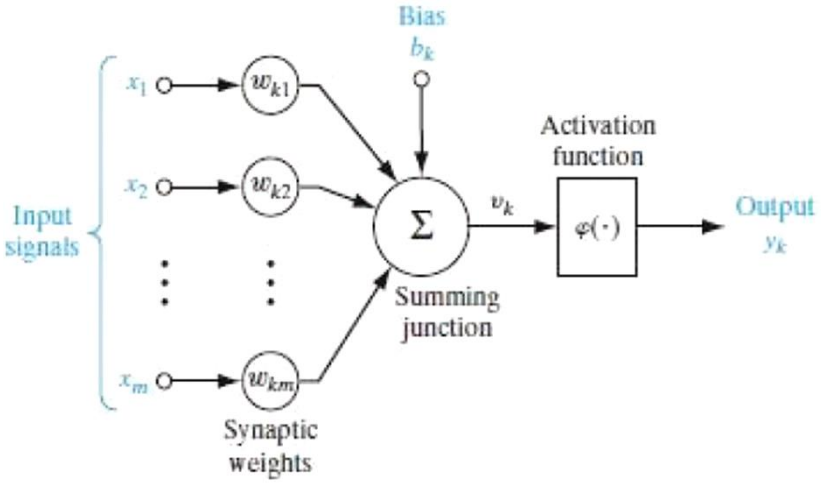

Figure 3 A block diagram of an artificial neuron

Four essential aspects of a neural model were recognized based on the block diagram (figure 3) and function of the neural network:

- Connecting links or synapses have a certain strength or weight in which the signal of the input Xi connected and linked to neuron k is multiplied by the wwki which is the synaptic weight.
- The adding of the weighted inputs together.
- A neuron's output is produced by an activation function. It's also known as a squashing function since it reduces (limits) the output signal's amplitude range to a limited value.
- According to the bias bk is equals positive or negative number, it makes the effect of boosting or reducing the net sum of input of function of the activation (Zayegh & Al Bassam, 2018).

Models of Neural Network

The learning method used in training an artificial neural network is inextricably related to the way the network's neurons are constructed. For the neural network, there are three primary models that are currently recognized.

1. Single-layer Feed-forward Neural Network

As it presented in (figure 4) the neurons of the model of a layered artificial neural network are grouped into layers. The model of single-layer feed-forwarded network, which consists of input nodes coupled to output nodes, is the most basic topology (P. Vishwakarma & N. Gupta, 2011).

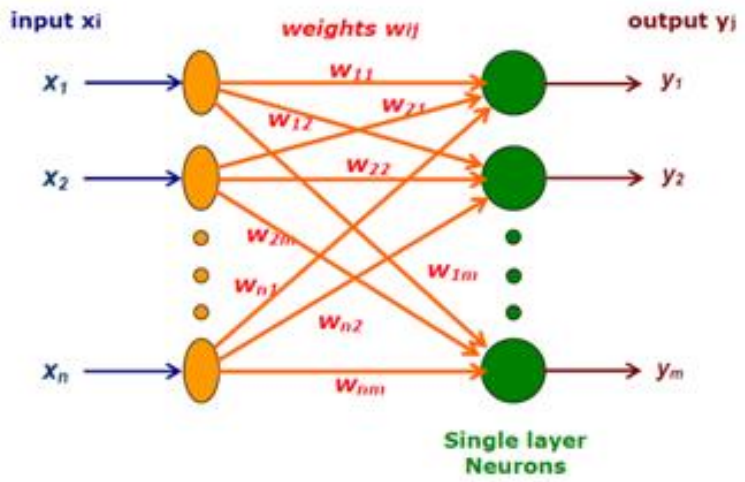

Figure 4 Single layer feed-forward neural network

2. Multi-layer Feed-forward Neural Network

The second class of a feed-forward neural network is called multi-layer which is differentiate itself by the existence more than one hidden layer, whose computation nodes are referred to as hidden neurons as observed in (Figure 5) (Aizenberg & Moraga, 2007).

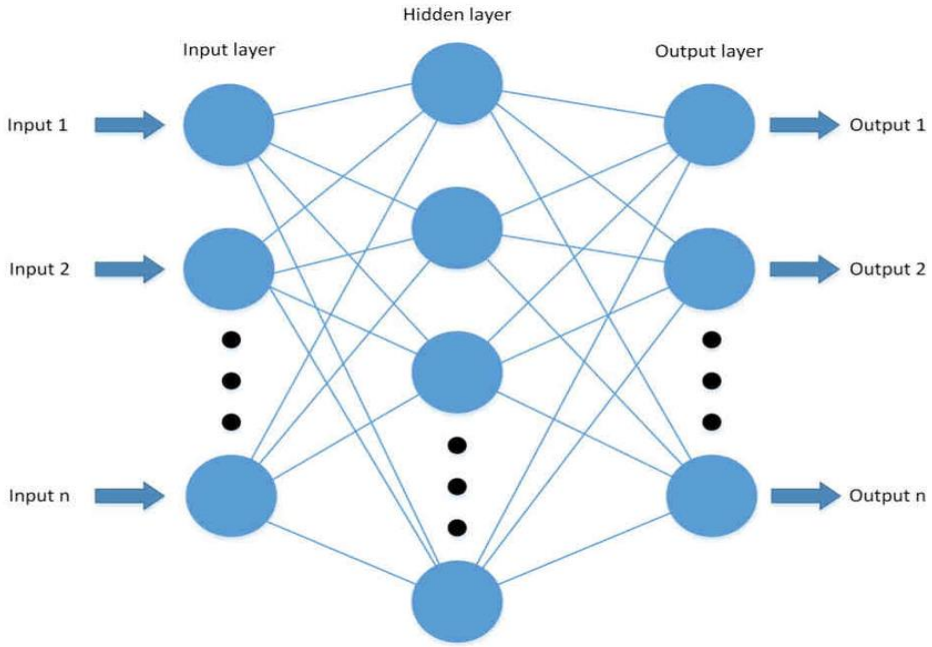

Figure 5 A multi-layer neural network

The network may extract higher-order statistics from its input by adding maybe one or more of hidden layers.

Training Methods for Neural Network

Simply, the training of neural network is the process of calibrating both values of biases and weights of the network, this process is applied to perform the wanted function in a correct way.

Learning and training methods of neural networks are mainly classified into:

1. Supervised Training or Learning

I this type of learning, the data set will be presented and addressed in a form of couples data (Input and desired output), after that the algorithm of learning will adapt the biases and the weights depending on false and error signals among the current real output and the desired one (Learning & Learning, 2010).

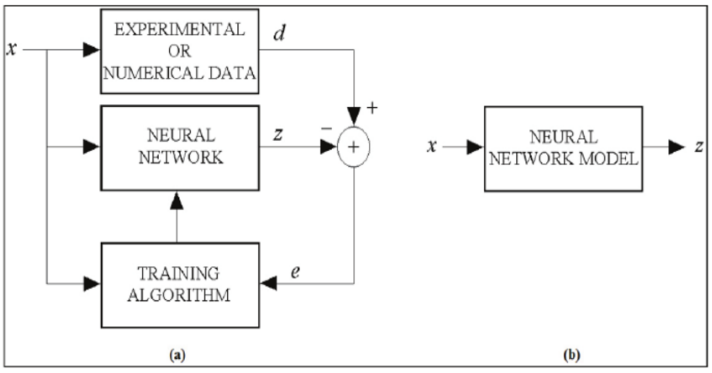

Figure 6 Supervised learning

2. Unsupervised Learning

In this learning model, a competitive rule is used, for example, the usage of neural network that composed of two layers which are input and competitive layers, the input layer works to receive the available set of data, the competitive layer is composed of some neurons that compete with each other according to the pattern of their learning method for the "opportunity" to react and respond to features presented in all input data as shown in (Figure 7) (Lunardi & Lima, 2021).

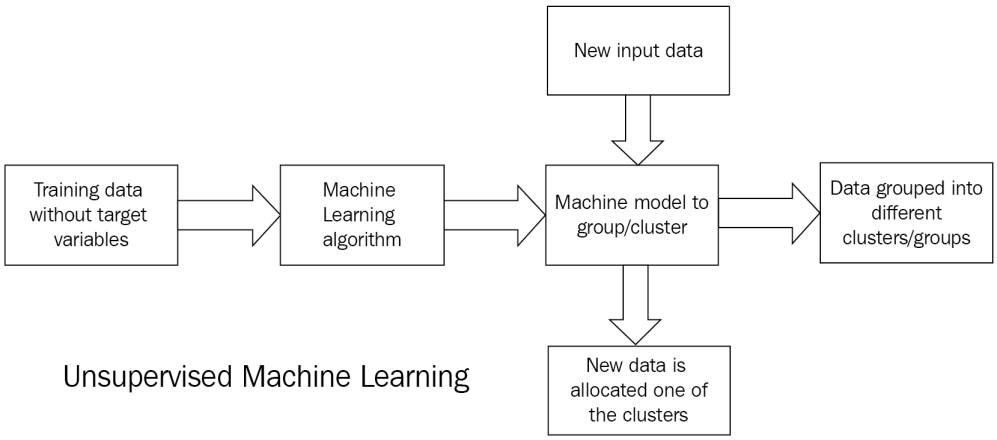

Figure 7 A block diagram for unsupervised learning

Different Applications of Neural Network

1. Human Face Recognition

The difficulty of recognizing and authenticating persons in photographs based on their faces shapes is called face recognition technique**.** It is mainly a skill which humans accomplish routinely, during the varied lighting and when features alter obscured by accessories and age or facial hair. Until recent time, it is still a difficult and hard computerized vision

challenge**.** Deep learning methods and approaches based on neural networks can exploit enormous datasets of faces expressions and shapes to compact and create representations of different faces, that allows contemporary example models to act as well as, and eventually surpass human face recognizing process capabilities (Syafeeza, Khalil-Hani, Liew, & Bakhteri, 2014).

Because artificial neural networks can imitate the way in which neurons operate inside human brain, they can be employed in face detection and identification. This is the primary reason for its importance in face recognition.

Face detection by ANN begins with the application of a series of neural network-based filters on a picture, followed by the arbitrage of the filter outputs. The filters scan each position in the image at various scales, seeking for areas that may contain a face. Following that, the arbitrator mixes detections from individual filters and removes overlapping detections (Feng, An, & Li, 2018).

Regular neural networks are generally uses vectors as a way to input, it also have completely connected layers that implies each element that connected and linked to all nodes within the layer above. The images must then be transformed within vectors, with number of weights among the input layer and single one node in the hidden layer which equals to the total number of pixels. All larger photos would result in an excessive number of weights.

Convolutional neural networks (CNNs) employ photos and pictures as an input and number of convolution kernels (weighted convolutions) as connections to the next layer. This implies that weights are distributed over multiple spatial places, and the number of weights required is reduced. These number of weights are even organized in 3D pattern volumes and turn the input picture to an output by a set of node activations. (Habrman, 2016).

According to (Rowley, 1996) Future work might go in a number of different areas. The present system's biggest restriction is that it only recognizes upright faces staring at the camera. Separate versions of the system might be trained for various head positions, and the results could be integrated using arbitration procedures similar to those described here.

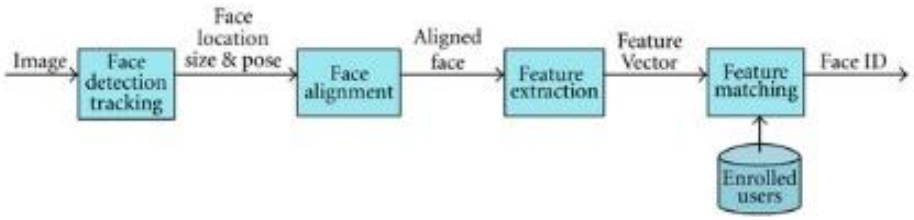

Figure 8 Face recognition via neural network

2. Aero Scope

The aerospace sector has been at the forefront of adopting innovations to generate a wide range of diversified and highly designed new products, new manufacturing techniques, and improved post-production aftermarket services. The aerospace manufacturing ecosystem includes a diverse range of industry actors such as airlines, aircraft manufacturers, airports, air traffic control, regulators, ground support, and an extensive network of tiered suppliers. Because legacy operational technologies were not meant to be networked, they only operate in their own context. As a result, information transmission and interoperability across this vast aerospace ecosystem have become slower and more fragmented (John, 2010).

A neural aerospace firm makes use of new technologies to create a robust, adaptable, and intelligent value chain that is backed by purpose-driven and networked partners. This type of extended aerospace value chain ecosystem, supported by numerous digital technologies, resembles the human brain network, allowing for high interoperability and information flow in all directions. This is what we mean by Neural Manufacturing for Aerospace: a highly connected, intelligent, robust, automated, adaptable, customized, and cognitive environment. This study focuses on the fundamental components of a neural aerospace firm and the benefits that neural ecosystems may provide to the aerospace sector.

Aerospace engineering is a broad phrase that encompasses advances in spacecraft and aeroplanes. Some of the important areas that neural networks have taken over are fault diagnostics, high performance auto piloting, safeguarding aviation control systems, and modelling crucial dynamic simulations. Delay in time nonlinear time dynamic systems may be modelled using neural networks (Paul et al., 2010).

Delay in Time For location independent feature recognition, neural networks are utilized. The method created using time delay neural networks can identify patterns. (Neural networks build patterns automatically by replicating the original data from feature units.)

TNN are also utilized to bring greater dynamics to NN models, in addition to this. Because passenger safety is of the highest importance inside an aeroplane, neural network algorithms maintain precision in the autopilot system. Because the majority of autopilot operations are automated, it is critical to guarantee that they be done in a secure manner (Paul et al., 2010).

Figure 9 Neural network in aerospace manufacturing

3. Neural Networks in Stock Market Prediction

As an intelligent mining of data approach, artificial neural networks (ANNs) have been utilized to solve a nearly wide range of difficult pattern identification tasks, including stock market prediction, one of the most challenging limitation among time series data analysis is predicting and watch stock performance. Over the last several decades, different machine learning algorithms have been identified as routinely employed to forecast financial time series. Despite the fact that automated trading systems based on Artificial Intelligence (AI) have grown popular, despite the fact that this is a typical issue, there are few cases that successfully exploit the established approach created (Gu, Shibukawa, Kondo, Nagao, & Kamijo, 2020). By human stock traders in order to create automated trading systems for example:

- Long Short-Term Memory Networks

Long-Term/Short-Term Memory artificial neural networks, often known as "LSTMs," which are a type of RNN that include a mechanism of gating that regulates and rearrange access linkage to memory cells. LSTM and its variants have showed considerable promise in solving numerous sequence modelling challenges in machine deep learning, including as natural processing language, picture taking, saving, and captioning, and audio recognizing

processes, since the introduction of the gates. A LSTM unit is made up of three gates: an input, forget, and an output gate (Song, Zhou, & Han, 2018).

- Concatenated Double-Layered LSTM for Predicting Stock Performance

The theory presents an LSTM-based network for predicting stock performance through categorization. Based on historical sequence data, the suggested network divides equities into two groups (buying or selling). In sequence data processing, the "Many to One" approach is commonly employed. To over control and use LSTM's memory in addition to forget capabilities options, the network has a "many to one" architecture design too. This indicates that when categorizing the stocks into two groups (buying or not) (Wanjawa & Muchemi, 2014).

4. Neural Network and Social Media

The typical humdrum path of life has been disrupted by social media. The behavior of social media users is studied using Artificial Neural Networks. Data exchanged through virtual dialogues on a daily basis is compiled and evaluated for competitive analysis.

Neural networks replicate the actions of social media users. Following an investigation of people's behavior via social media networks, the data may be connected to their spending patterns. Multilayer Perceptron ANN is used to harvest data from social media apps.

MLP anticipates social media trends by combining a number of training approaches, includes Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), and Mean Squared Error (MSE) (MSE). MLP takes into account a number of parameters, including the user's favorite Instagram sites, bookmarked alternatives, and so on. These variables are used as inputs for training the MLP model (Le, Pardo, & Claster, 2016).

- Convolution neural network in Social Media

The technique of producing feature maps from input data is known as convolution. CNN has grown in popularity for image data extraction, particularly for extracting picture features and components. CNNs may also be used to produce image descriptions automatically (Pérez-Sánchez, 2011).

CNNs differ from neural networks in that they turns all input data and transform it to neurons dimensional vector. CNNs match the structural-data it records using spatial structure, which aids in the classification of photos, videos, and so on.

The sharing of weights between neuron receptive field structures and neurons is one of the most noticeable aspects of employing CNN. Neural networks utilize and uses models of unsupervised and supervised learning to edit and modify the weights in order to achieve the best classification results. Among the many advantages of enhanced extension distance utilizing CNNs are quick training time, ease of maintenance, and excellent adaptability (R, Rohmetra, & Mungad, 2008).

The basic structure of CNN alternates between convolutional and pooling layers. This pairing will continue until the data reduction is completed and all of the feature upcoming maps are entered and integrated into a total Full Connected Layer (FCL). The structure of CNN is separated into modules for feature option extraction and classification. The rest of the section is made up of convolution layers that alternate with subsampling differentiated layers, with the convolution layer containing multiple and random generated (2D) two-dimensional shared of weights (Hussain, Keshavamurthy, & Wazarkar, 2017).

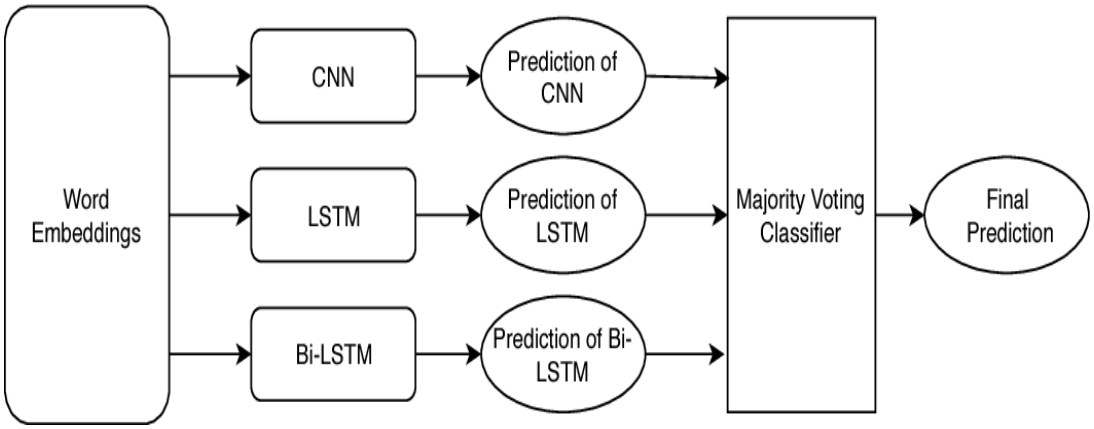

Figure 10 Neural network in social media application

5. Climate and Weather Forecasting

For decades, computer models that built on physical equations knowledge – known as the models of numerical weather prediction (NWP), weather forecasting dominated synoptic (forecasting the weather with lead periods ranging from a only few days extended to two weeks), the quality of NWP forecasts has gradually improved, and these models continue to constitute the foundation of practically all weather forecasts.

Most ANNs are adaptive systems that modify their structure according to internal or external information which travels through the neural network across the deep learning period. Modern newly neural networks are mathematical and statistical data modelling methods that are in non-linear form. They are typically used to represent complicated

interactions among inputs and outputs or to look for patterns in data setS (Scher & Messori, 2019).

ANNs are effective tools for modelling designing of nonlinear relationships among dependent and independent different variables. They are inspired and designed based on biological nerve systems. Remarkable ANNs' characteristics is the generalization option, which makes them able to anticipate patterns that were not supplied to them during deep learning training. As a consequence, ANN forecasting models outperform physical and statistical techniques in terms of performance. They are also easy to access as a toolbox in regularly used different programming environments.

To anticipate air temperature, many different types of ANNs like recurrent neural network (RNN), neural network (CNN), multi-layer perceptron (MLP), long short-term memory (LSTM), convolutional and so on) have been widely used. Each kind has its own framework for learning and forecasting air temperature trends. However, because of complicated nature and chaotic of air temperature data set, reliable air temperature forecasting has been a serious difficulty for many decades (particularly as the forecast time horizon rises) (Baboo & Shereef, 2010).

ANNs were trained using historical and saved temperature in addition to other micrometeorological set of data as inputs. Furthermore, the number of unobserved neurons has a significant impact on prediction accuracy. The amount of hidden unobserved neurons is usually determined through trial and also by error findings.

Generally, different models of neural network have been proven to be very promising and have the ability of providing and making accurate and deep air temperature focusing forecasts. So, it is expected that artificial neural networks will act as a key role within the process of air temperature identification and prediction in the upcoming future. (Tran, Bateni, Ki, & Vosoughifar, 2021).

Advantages and Limitations of Neural Networks

1. Advantages

- Storing and saving sets of information on the whole available space of network: all the available data and information can be stores on the network instead of week databases. Because traditional known programming, few pieces and amounts of information disappeared in one single location in which does not render the network inoperable.

- Their significant ability to operate and merge with incomplete pieces of knowledge: after finishing the training of artificial neural network, all data might extract and output even if the information is not complete and partial.
- Fault tolerance: If one or more ANN cells are corrupted by anyway, the system will still provide output. This promising feature improves network failure tolerance. (Jain, Mao, & Mohiuddin, 1996).
- Distributed memory characteristics: artificial neural network needs learn models by network determination which forcibly needs to be taught according to its intended output by send different examples to network, the success of the network is usually in a direct proportional relationship with the chosen example, and so if the action cannot be displayed to network, the ANNs will generate other output.(Mijwil, 2018).
- Gradual corruption will appear when a network degrades and slow over the passing of time. The network problem does not repair and manifest itself as quickly as possible.
- The ability of machine learning: Artificial neural networks works to learn different events and take right choices by commenting and reacting on similar events.
- The ability of parallel processing: Artificial neural networks have the power of numerical strength points to accomplish and achieve several tasks at the same time.

2. Limitations of Neural Network

- Reliance of hardware: due to their design and structure, ANNs need processors with equal parallel processing capacity systems. Therefore, the realization of equipment is quietly dependent.
- Unexplained network behavior for some types of ANNs. For example: When ANN creates an actual probing solution, it only acts without explanation by why or how. This unobvious action is undermines network trust.
- Difficulty in presenting and explaining the problem properly to the network: ANNs has the ability to deal with numerical set of data. Before the step of introducing problems to artificial neural networks, they firstly needs be converted and transformed into numerical values. The method of display used to have a direct obvious impact on network performance actions. (Navarro & Bennun, 2014).
- The lifespan of ANNs network is still unknown yet: The training is finished when the network is lowered to a specific value of the error on the sample. This configuration does not get the greatest results (Lancashire, Lemetre, & Ball, 2009).

Conclusion

Artificial neural networks may be conceived of as simplified versions of the natural networks of neurons seen in the animal brain. The basic criteria for a neural network from a biological standpoint is that it seek to represent what we feel are the main information processing qualities of the corresponding "actual" network. This correspondence is unimportant to an engineer, and the network provides an alternate kind of parallel computing that may be more suited for tackling the issue at hand.

Many computer languages, including Python, R, MATLAB, C, and Java, may be used to create neural networks. The emphasis of this book will be on developing applications in R. On the basis of neural networks, DNN and AI systems are emerging. In the next chapter, we will go through several types of neural networks and their applications.

References

Abe, S. (1997). Overview of Neural Networks. *Neural Networks and Fuzzy Systems*, 1–5. https://doi.org/10.1007/978-1-4615-6253-5_1

Aizenberg, I., & Moraga, C. (2007). Multilayer feedforward neural network based on multi-valued neurons (MLMVN) and a backpropagation learning algorithm. *In Soft Computing*, *11*, 169–183. https://doi.org/10.1007/s00500-006-0075-5

Baboo, S.S., & Shereef, I.K. (2010). An efficient weather forecasting system using artificial neural network. *International journal of environmental science and development*, *1*(4), 321-326.

Farizawani, A.G., Puteh, M., Marina, Y., & Rivaie, A. (2020). A review of artificial neural network learning rule based on multiple variant of conjugate gradient approaches. *Journal of Physics: Conference Series*, *1529*(2). https://doi.org/10.1088/1742-6596/1529/2/022040

Feng, Y., An, X., & Li, S. (2018). Research on Face Recognition Based on Ensemble Learning. *In 37th Chinese Control Conference (CCC)*, 9078-9082. https://doi.org/10.23919/ChiCC.2018.8484211

Gu, Y., Shibukawa, T., Kondo, Y., Nagao, S., & Kamijo, S. (2020). Prediction of stock performance using deep neural networks. *Applied Sciences (Switzerland)*, *10*(22), 8142. https://doi.org/10.3390/app10228142

Habrman, D. (2016). *Face Recognition with Preprocessing and Neural Networks*. Master of Science Thesis, 1–39. https://liu.diva-portal.org/smash/get/diva2:931705/FULLTEXT01.pdf

Hahn, C. (2008). The nervous system. *In Color Atlas of Diseases and Disorders of the Foal*, 347-377. https://doi.org/10.1016/B978-0-7020-2810-6.50019-9

Hussain, A., Keshavamurthy, B.N., & Wazarkar, S. (2019). An efficient approach for classifying social network events using convolution neural networks. *In Advances in Data and Information Sciences*, Springer, 177-184.

Jain, A.K., Mao, J., & Mohiuddin, K.M. (1996). Artificial neural networks: A tutorial. *Computer*, *29*(3), 31–44. https://doi.org/10.1109/2.485891

Lary, D.J. (2010). Artificial Intelligence in Aerospace. *Aerospace Technologies Advancements*, 492-516. https://doi.org/10.5772/6941

Lancashire, L.J., Lemetre, C., & Ball, G.R. (2009). An introduction to artificial neural networks in bioinformatics - Application to complex microarray and mass spectrometry datasets in cancer studies. *Briefings in Bioinformatics*, *10*(3), 315–329. https://doi.org/10.1093/bib/bbp012

Le, T., Pardo, P., & Claster, W. (2016). Application of artificial neural network in social media data analysis: A case of lodging business in Philadelphia. *Studies in Computational Intelligence*, *628*, 369–376. https://doi.org/10.1007/978-3-319-28495-8_16

Learning, S., & Learning, M. (2010). *Supervised Learning in Neural Networks The Backpropagation Algorithm : Gradient Descent Training of ANNs*. 1–21.

Lunardi, A.R., & Lima, F.R. (2021). Comparison of artificial neural networks learning methods to evaluate supply chain performance. *Gestao e Producao*, *28*(3). https://doi.org/10.1590/1806-9649-2021V28E5450

Mijwil, M.M. (2018). Artificial Neural Networks Advantages and Disadvantages. https://www.researchgate.net/publication/323665827

Navarro, H., & Bennun, L. (2014). Descriptive Examples of the Limitations of Artificial Neural Networks Applied to the Analysis of Independent Stochastic Data. *International Journal of Computer Engineering and Technology*, *5*, 40–42.

Özturan, M., Bozanta, A., Basarir-Ozel, B., Akar, E., & Coşkun, M. (2015). A roadmap for an integrated university information system based on connectivity issues: Case of Turkey. *The International Journal of Management Science and Information Technology (IJMSIT)*, (17), 1-22.

Vishwakarma, V.P., & Gupta, M.N. (2011). A new learning algorithm for single hidden layer feedforward neural networks. *International Journal of Computer Applications*, *28*(6), 26-33. https://doi.org/10.5120/3390-4706

Paul, S., Kapoor, K., Jasani, D., Dudhwewala, R., Gowda, V.B., & Nair, T.R.G. (2010). *Application of Artificial Neural Networks in Aircraft Maintenance, Repair and Overhaul Solutions*. http://arxiv.org/abs/1001.3741

Pérez-Sánchez, R. (2008). Between neural networks and social networks: Between recognition and discrimination. *Actualidades en psicología*, *22*(109), 131-133. https://doi.org/10.15517/ap.v22i109.22

Ahan, M.R., Rohmetra, H., & Mungad, A. (2018). Social network analysis using data segmentation and neural networks. *International Research Journal of Engineering and Technology (IRJET)*.

Rowley, H.A. (1996). *Neural Network-Based Face Detection*.

Scher, S., & Messori, G. (2019). Weather and climate forecasting with neural networks: using general circulation models (GCMs) with different complexity as a study ground. *Geoscientific Model Development*, *12*(7), 2797-2809. https://doi.org/10.5194/gmd-12-2797-2019

Song, Y.G., Zhou, Y.L., & Han, R.J. (2018). Neural networks for stock price prediction. *arXiv preprint arXiv:1805.11317*. http://arxiv.org/abs/1805.11317

Sturges, P. (2013). The Human Brain and Information Science: Lessons from Popular Neuroscience. *International Journal of Knowledge Content Development & Technology*, *3*(1), 19–29. https://doi.org/10.5865/ijkct.2013.3.1.019

Syafeeza, A.R., Khalil-Hani, M., Liew, S.S., & Bakhteri, R. (2014). Convolutional neural network for face recognition with pose and illumination variation. *International Journal of Engineering & Technology*, *6*(1).

Tran, T.T.K., Bateni, S.M., Ki, S.J., & Vosoughifar, H. (2021). A review of neural networks for air temperature forecasting. *Water (Switzerland)*, *13*(9), 1294. https://doi.org/10.3390/w13091294

Wanjawa, B.W., & Muchemi, L. (2014). *ANN Model to Predict Stock Prices at Stock Exchange Markets*, http://arxiv.org/abs/1502.06434

Zayegh, A., & Al Bassam, N. (2018). *Provisional chapter Neural Network Principles and Applications*.