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# Artificial Neural Network Systems

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**ABSTRACT**

*Artificial Neural Networks is a calculation method that builds several processing units based on interconnected connections. The network consists of an arbitrary number of cells or nodes or units or neurons that connect the input set to the output. It is a part of a computer system that mimics how the human brain analyzes and processes data. Self-driving vehicles, character recognition, image compression, stock market prediction, risk analysis systems, drone control, welding quality analysis, computer quality analysis, emergency room testing, oil and gas exploration and a variety of other applications all use artificial neural networks. Predicting consumer behavior, creating and understanding more sophisticated buyer segments, marketing automation, content creation and sales forecasting are some applications of the ANN systems in the marketing. In this paper, a review in recent development and applications of the Artificial Neural Networks is presented in order to move forward the research filed by reviewing and analyzing recent achievements in the published papers. Thus, the developed ANN systems can be presented and new methodologies and applications of the ANN systems can be introduced.*

**Keywords:** Artificial Neural Networks, Artificial Intelligence

**Mathematics Subject Classification:** 68T01, 68T05

**Journal of Economic Literature (JEL) Classification :** C7

## 1. INTRODUCTION

Artificial Neural Networks (ANNs), or more simply neural networks, are new systems and computational methods for machine learning, knowledge demonstration, and finally the application of knowledge gained to maximize the output responses of complex systems (Chen et al. 2019). An Artificial Neural Network (ANN) is a data processing model based on the way biological nervous systems, such as the brain, process data. They're focused on the neuronal structure of the mamalian cerebral cortex, but at a much smaller scale. Many artificial intelligence experts believe that artificial neural networks are the

best and perhaps the only hope for designing an intelligent machine. The branches and sections of the computational methods as well as Artificial Neural Networks in the chart is shown in the figure 1.

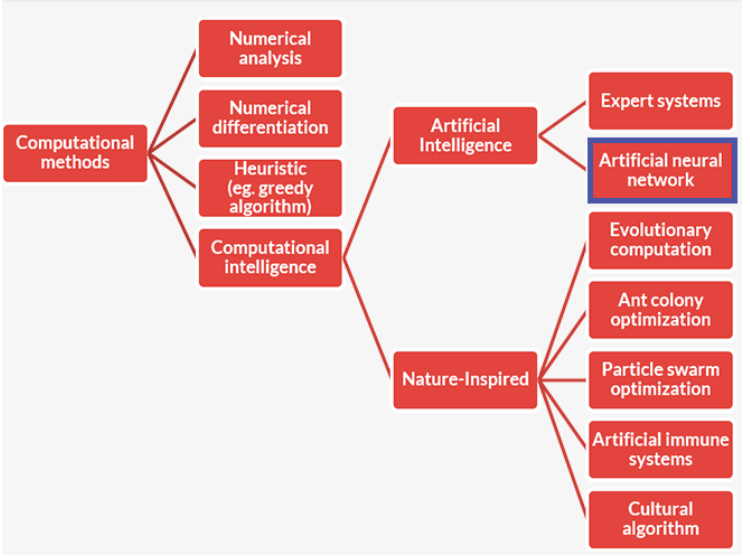


**Figure 1.** The branches and sections of the computational methods.

Artificial neural networks are designed in the same way as the human brain, with neuron nodes interconnected in a web-like fashion. Neurons are billions of cells that make up the human brain. Each neuron is made up of a cell body that processes information by bringing it to and from the brain (inputs and outputs) (Van Gerven and Bohte 2017). The main idea of such networks is (to some extent) inspired by the way the biological neural system works, to process data, and information in order to learn and create knowledge. The key element of this idea is to create new structures for the information processing system. The Artificial neural network architecture is shown in the figure 2 (Bre, Gimenez, and Fachinotti 2018).

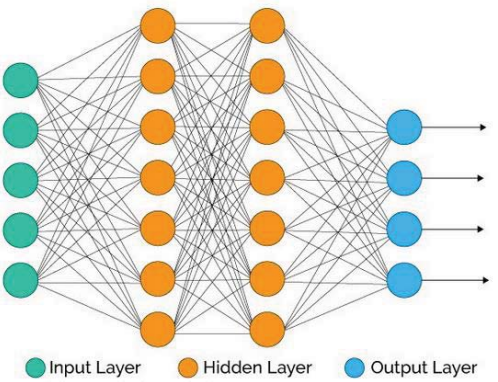


**Figure 2.** Artificial neural network architecture (Bre, Gimenez, and Fachinotti 2018).

The system is made up of a large number of highly interconnected processing elements called neurons that work together to solve a problem and transmit information through synapses (electromagnetic connections). The neurons are interconnected closely and organized into layers. The input layer receives the data, while the output layer generates the final result. Between the two, one or more secret layers are typically sandwiched. This arrangement makes predicting or knowing the exact flow of data difficult.

Each connection has a connection weight, and each neuron has a threshold value and an activation function (Balakrishnan et al. 2019). It is calculated if each input has a positive or negative weight based on the sign of the input's weight. The weight affects the signal intensity at a connection (Liu et al. 2018). Neurons which have a threshold above which a signal is only transmitted if the aggregate signal exceeds it. The Activation Value is the weighted sum of the summing unit, and the output is generated based on the signal from this activation value. The relation between weight of each element and input and output of the ANN system is shown in the figure 3.

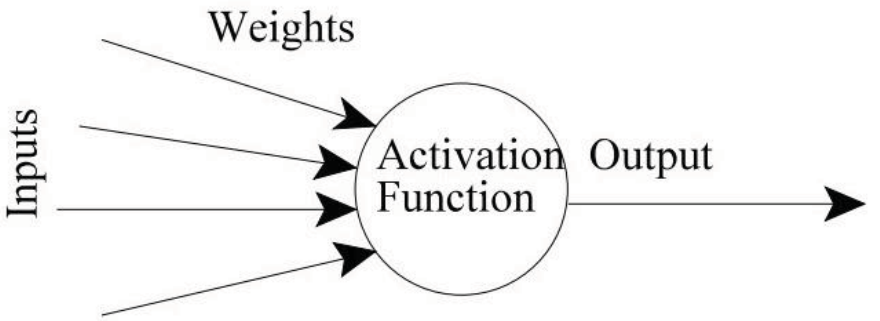


**Figure 3.** Weight of each element and input and output of the ANN system.

In these networks, if one cell is damaged, other cells can make up for its absence and contribute to its regeneration. These networks are capable of learning. Basically, the ability to learn is the most important feature of an intelligent system. A learning system is more flexible and easier to program, so it can better respond to new problems and equations. Artificial neural networks, like humans, learn by using the different examples, and a neural network is set up to perform specific tasks, such as identifying patterns and categorizing information, during a learning process. For example, by injecting tactile nerve cells, the cells learn not to go to the hot body, and with this algorithm, the system learns to correct its error.

Artificial neural networks are increasingly used in the control or modeling of systems that have unknown or very complex internal structures. For example, a neural network can be used to control the input of an engine, in which case the neural network itself will learn the control function. Learning in these systems is adaptive, that is, using parables, the weight of the synapses changes in such a way that the system produces the correct response if new inputs are given (Wu and Feng 2018). A neural network is given a set of inputs and their corresponding outputs when it is being trained (using one of the training methods).

To analyze and modify the machining operations in virtual environments, virtual machining systems and applications are presented by Soori et al. (Soori, Arezoo, and Habibi 2017, 2014, 2013; Soori and Arezoo 2021; Soori, Arezoo, and Habibi 2016). Application of the Secure Socket Layer in the Network and Web Security is investigated by Dastres and Soori (Dastres and Soori 2020b) to increase the security measures in the web of data. The impact of meltdown hole on various processors and operating systems are studied by Dastres and Soori (Dastres and Soori 2020a) in order to increase security of CPU manufacture by preventing the capturing data on computer or smartphones by attackers. . A review in recent development of network threat and security measures is presented by Dastres and Soori (Dastres and Soori 2021b) to classify the presented research works and suggest some future research trends. Advanced image processing systems is reviewed by Dastres (Dastres and Soori 2021a) and Soori to introduce new techniques in the image processing systems.

There are two Artificial Neural Network topologies as FeedForward and Feedback. In the feed forward systems, there are no feedback loops, because a unit sends information to another unit from which it receives none. Inputs and outputs are fixed. Each unit receives input information from its units on the left, and the inputs are multiplied by the weight of each connections. So, the output results related to the weight of each connections can be obtained. Pattern generation, identification, and classification are some application of the method. The system is applied to the network applications when already know what outcome of the network is required to be achieved (Al-Zewairi, Almajali, and Awajan 2017). Many commercial applications, such as computer vision, are built on this foundation. The architecture of FeedForward Neural Network topologies systems are shown in the figure 4 (Mitra and Paul 2017).

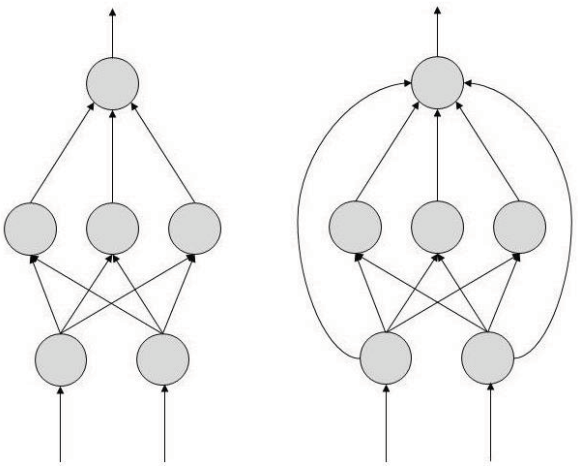

**Figure 4.** The architecture of FeedForward Neural Network topologies systems (Mitra and Paul 2017).

In the FeedBack ANN systems, content addressable memories are used. Learning neural networks using a feedback process is by comparing the output of a network with the output that is desired and expected. The difference between these two outputs is used to change and modify the weights of the connections between the network units. The architecture of FeedBack ANN systems are shown in the figure 5 (Mitra and Paul 2017).

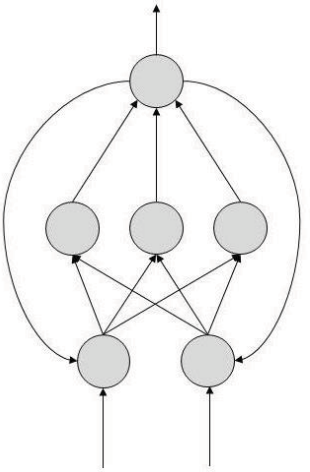

**Figure 5.** The architecture of FeedBack ANN systems (Mitra and Paul 2017).

## 2. ADVANTAGES AND DISADVANTAGES OF THE ANN SYSTEMS

Adaptive learning is the most important advantages of the ANNS systems. Ability to learn how to perform tasks based on information given for practice and introductory experiences (Rabault et al. 2019). For example, the system can learn the recognition of the letters T and H by using the adaptability and pattern structure. The process is shown in the figure 6 (Qasim 2013).

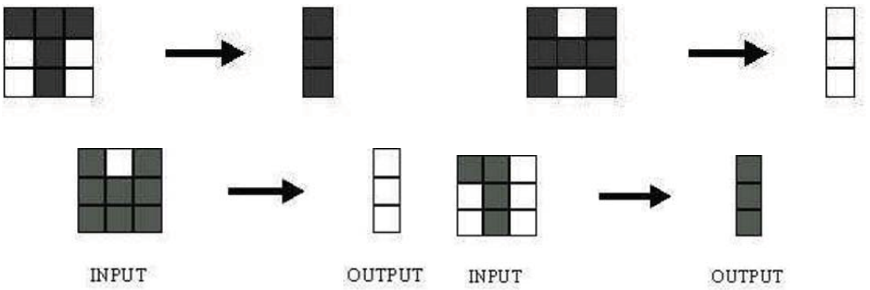


**Figure 6.** The recognition of the letters T and H by using the adaptability in the ANN systems (Qasim 2013).

The main advantage of using a neural network in any of the above issues is the extraordinary ability of the neural network in learning as well as the stability of the neural network in the face of minor disturbances (Chen et al. 2019). For example, if we use normal methods to detect a human handwriting, these methods may be misdiagnosed by a slight vibration of the hand, while a properly trained neural network can respond even in the event of such a disturbance. It will come true. An ANN can organize or present itself for the information it gains during the learning period. The learning abilities of the ANN systems is shown in the figure 7 (Qasim 2013).

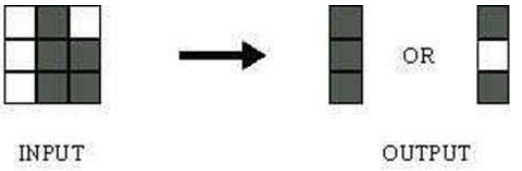


**Figure 7.** The learning abilities of the ANN systems (Qasim 2013).

Artificial neural network calculations can be applied in parallel, and special hardware in order to provide the Real time performance applications.

Tolerance of error without interruption when encoding information: A partial failure of a network leads to a corresponding degradation of its performance, although a number of network capabilities may remain even with great damage. Due to the high speed of neural networks in data processing and analysis, the time required to discover the optimal structure is reduced (Wu and Feng 2018).

Despite the advantages that neural networks have over conventional systems, they also have disadvantages that researchers in this field are trying to minimize, including: 1. there are no specific rules or instructions for designing a network for an optional application. 2. In the case of modeling problems, the physics of the problem alone cannot be understood using neural networks. In other words, linking parameters or network structure to process parameters is usually impossible. 3. The accuracy of the results depends a lot on the size of the training set. 4. Network training may be difficult or even impossible. 5. It is not easy to predict the future performance of the network (generalization) (Walczak 2019).

## 3. DEEP LEARNING

ANN systems should be more complex in order to represent more complex features and "read" increasingly complex models for prediction and classification of data based on thousands or even millions of features. Deep learning is a machine learning subfield that focuses on learning successive "layers" of increasingly meaningful representations while learning representations from data (Grekousis 2019). It is concerned with artificial neural networks (ANNs), which are algorithms based on the structure and function of the brain. Deep learning allows computational models with multiple processing layers to learn multiple levels of abstraction for data representations. They are neural networks that have more than three layers of neurons (including the input and output layers). These layered representations are learned using models known as "neural networks," which are organized into literal layers that are placed one on top of the other (Schmidhuber 2015). Simply increasing the number of hidden layers and/or the number of neurons per hidden layer accomplishes this. More layers and neurons can represent increasingly complex models, but they also require more time and power to compute. The architecture of Deep learning technologies is shown in the figure 8 (Santos et al. 2021).

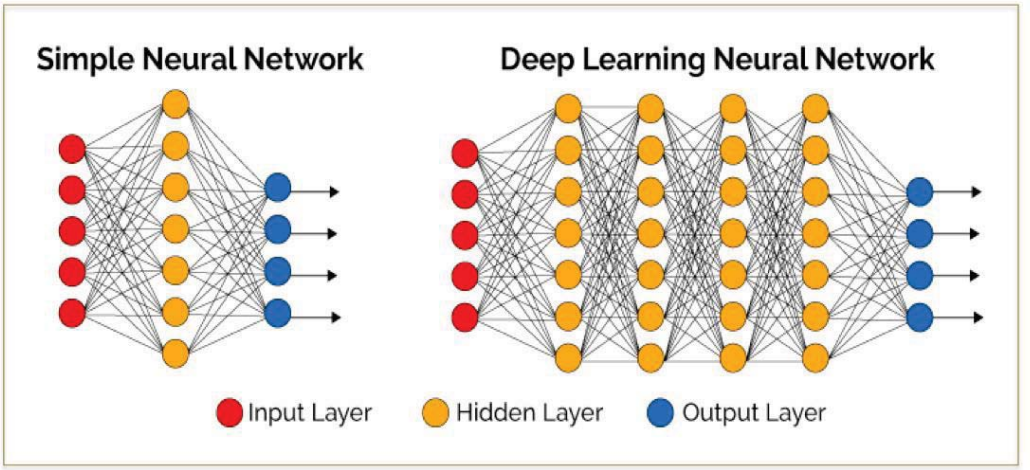


**Figure 8.** The architecture of Deep learning technologies (Santos et al. 2021).

Deep learning technologies and their possible advantages/benefits are various. Using self-driving cars as an example, the "need to train a machine to take over key parts (or all) of driving is addressed.

## 4. APPLICATIONS OF THE ANN SYSTEMS

Today, neural networks are used in a variety of applications, such as pattern recognition issues, which include issues such as line recognition, speech recognition, image processing, and the like, as well as categorization issues such as text or image classification (Li, Zhang, and Liu 2017). Other applications of neural networks include risk analysis systems, drone control, welding quality analysis, computer quality analysis, emergency room testing, oil and gas exploration, truck braking detection systems, loan risk estimation, spectral detection, drug detection. Industrial control processes, error management, voice recognition, hepatitis detection, remote information retrieval, submarine mine detection, 3D object and handwriting and face detection, etc. Calculate a known function, approximation of an unknown function, Pattern identification, signal processing are some applications of the ANNs (Li, Zhang, and Liu 2017). Modeling of Wear Rate and Friction Coefficient by using the ANNs in reinforced Magnesium metal matrix composite is presented by Kavimani and Prakash (Kavimani and Prakash 2017) to increase the accuracy in prediction of specific wear rate value based on the variation of input parameter. Prediction of surface roughness in the end milling machining using Artificial Neural Network is presented by Zain et al. (Zain, Haron, and Sharif 2010) to obtain the best surface roughness value is a high speed with a low feed rate and radial rake angle in milling operations. Predicting performance of Wire Electrical Discharge Machining of Inconel 718 Alloy by using the advanced ANN system is presented by Lalwani et al. (Lalwani et al. 2020) to increase quality of machined parts. The application of the ANN systems in the signal processing systems is shown in the figure 9 (Cichocki, Unbehauen, and Swiniarski 1993).

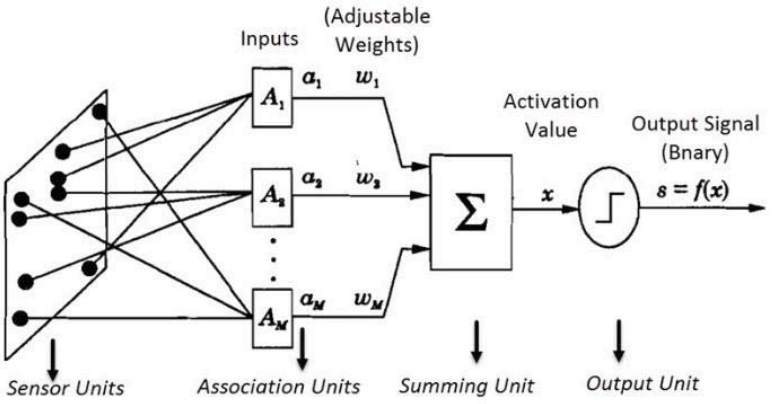


**Figure 9.** The application of the ANN systems in the signal processing systems (Cichocki, Unbehauen, and Swiniarski 1993).

Applications of the developed ANN systems in the wind energy monument systems is presented by Marugán et al. (Marugán et al. 2018) to increase efficiency in energy production systems. Prediction of wind speed and wind direction using artificial neural network is investigated by Khosravi et al. (Khosravi et al. 2018) to increase efficiency in the wind turbine systems. Modeling of solar energy systems using artificial neural network is reviewed by Elsheikh et al. (Elsheikh et al. 2019) to predict and optimize the performance of different solar energy devices.

Artificial neural networks applications in the drinking water sector is investigated by O'Reilly et al. (O'Reilly, Bezuidenhout, and Bezuidenhout 2018) in order to develop the water purification facilities in South Africa.

In the Pattern recognition system, the ANN can be applied to the face recognition, fingerprint, voice and speech recognition and handwriting (Melin and Sánchez 2018). For example, this mechanism is used in banks to compare the signature of the client to receive money from an account and the signature recorded in the account file. This is one of the first ubiquitous applications of neural network chips.

Noise in telecommunication lines can be detected and reduced in order to increase the quality of commination systems (Kashi et al. 2017). Applications of the Neural Networks in optical communication systems is investigated by Eriksson et al. (Eriksson, Bülow, and Leven 2017) in order to increase the quality of the communication Systems.

Business applications is another field of ANN systems. Marketing any decisions that are not easy to make in the business world, such as decisions that require extensive information in the target area (Ćetković et al. 2018). For example, in trying to predict stock fluctuations from previous information on the stock market, networks are optimally used (Qiu and Song 2016). Predicting consumer behavior, creating and understanding more sophisticated buyer segments, marketing automation, content creation and sales forecasting are some applications of the ANN systems in the marketing (Zakaryazad and Duman 2016). The area of predictive analytics is where artificial neural networks are most commonly used. In this case, neural networks can aid marketers in making predictions about a

campaign's outcome by identifying patterns from previous campaigns (Chattopadhyay et al. 2012; Sharma and Chopra 2013).

ANNs are also being used to monitor credit card transactions in order to detect possible fraud. In the marketing application, the ANN Networks are used to sell more and more selectively in Internet advertising (Li et al. 2018). Artificial Neural Networks architectures for stock price prediction is presented by Di Persio and Honchar (Di Persio and Honchar 2016) in order to predict financial time series movements and to develop the marketing systems. Data envelopment analysis and artificial neural network to online prediction performance of companies in stock exchange system is investigated by Rezaee et al. (Rezaee, Jozmaleki, and Valipour 2018) to increase finical performances of stock exchange companies.

The advanced ANN systems can compress visual information to reduce the amount of information (Ma et al. 2019). The ANN systems can be applied to the monitoring systems in order to increase quality as well as safety of different processes (Menke, Bornhorst, and Braun 2019). For example, by examining the sound levels transmitted from spacecraft, the dangers facing the spacecraft are predicted. This method has also been tested on rails to check the sounds produced by diesel engines. Since they can predict how ecosystems respond to changes in environmental variables, artificial neural networks (ANNs) are useful tools for modeling complex ecosystems (Coutinho et al. 2019).

In the medicine and healthcare applications, the ANN can be used in analyzing and diagnosing the symptoms of a pacemaker (electrocardiograph), as well as a trained network that can diagnose the disease and even prescribe medication (Jain et al. 2021). To predict the Tumor Category in the health care system, application of the ANN systems is developed by Nasser and Abu-Naser (Nasser and Abu-Naser 2019). Applications of artificial neural networks in health care organizational decision-making is reviewed by Shahid et al. (Shahid, Rappon, and Berta 2019) to develop the health care systems in the hospitals. Medical image processing by using the ANN systems is presented by Jiang et al. (Jiang, Trundle, and Ren 2010) to resolve problems relevant to medical imaging. Artificial Neural Networks in Image Processing for Early Detection of Breast Cancer is presented by Mehdy et al. (Mehdy et al. 2017) to increase quality of the health care systems. Parkinson's Disease Prediction Using Artificial Neural Network is investigated by Sadek et al. (Sadek et al. 2019) to increase the accuracy of prediction for the Parkinson's Disease.

## 5. CONCLUSION

An artificial neural network (ANN) is made up of artificial neurons, which are a series of linked units or nodes that resemble the neurons in a biological brain. Each link, similar to synapses in a biological brain, has the ability to send a signal to other neurons. Adaptive learning is the most important advantages of the ANNS systems. The learning rate determines how large the model's corrective steps are in adjusting for errors in each observation. A high learning rate reduces training time but reduces overall accuracy, while a low learning rate takes longer but has the potential for greater accuracy. Although ANNs can handle most tasks if they are given the opportunity to prepare for them, the biggest

challenge is the time it takes to train them and the computing power needed for a complex task. Performance of an ANN models in the complex problems strongly depends on the network architecture in order to achieve the best solutions for the simulated challenges.

When dealing with large datasets, neural networks are extremely useful. ANNs can run much faster than their linear counterparts when dealing with massive, continuous streams of data, such as speech recognition or computer sensor data. This means that the neural network has enough data to generate mathematical models of the data that has been inputted; this is why, with the amount of new data coming out every year, they are becoming more and more popular.

Self-driving vehicles, character recognition, image compression, stock market prediction, risk analysis systems, drone control, welding quality analysis, computer quality analysis, emergency room testing, oil and gas exploration and a variety of other applications all use artificial neural networks. ANNs have been used by large financial institutions to boost efficiency in areas such as bond ranking, credit scoring, target marketing, and loan application evaluation. The advanced ANN systems can be applied for modeling of complex engineering and physics problems in order to obtain the best solution.

Even though there are some approaches in making machines think and behave like humans, there's still a lot to discover. However, the work of researchers may be able to help neural networks eventually break the generational loop that has seen them in and out of favor for the past seven decades.

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