International journal of industrial engineering and operational research (IJIEOR)

Contents lists available at IJIEOR

International journal of industrial engineering and operational research

journal homepage: http://ijieor.ir

Volume 5, No. 1, 2023

Survey of Artificial Neural Networks and Applications

Pedram MohajerAnsari [a], Bahareh Kargar [b]

[a] *Department of Computer Engineering, Sirjan University of Technology, Sirjan , Kerman, Iran,*
[b] *Department of Industrial Engineering, Iran University of Science and Technology, Tehran, Iran.*

ARTICLE INFO

Received: 2023/06/01

Revised: 2023/08/01

Accept: 2023/08/29

Keywords:

Neural Network, System Functions, Computer System, Artificial Intelligence.

ABSTRACT

These days, machines have replaced humans in many cases, and many physical tasks that were performed by humans in the past are now done by machines. Although the power of computers in storage, retrieval of information, and administrative automation is undeniable, there are still instances where humans are obliged to carry out tasks themselves. In such systems, the brain cannot internally dissect and analyze the system and merely guesses the internal operation of the system based on external behaviors and predicts its reactions. Over time, the human brain, by observing the sequence of system behaviors and occasionally experimenting, can identify the habits of the system to some extent as a result of manipulating one of the components of the system. This learning process, as a result of observing varied examples from the system, leads to gaining experience.

1. Introduction

Neural networks can be broadly termed as electronic models of the human brain's neural structure. The mechanism of learning and teaching in the brain is essentially based on experience. Electronic models of natural neural networks are also built on the same pattern, and their approach to problem-solving differs from the computational methods typically employed by computer systems. We know that even the simplest animal brains can solve problems that, if not to say today's computers are incapable of solving, they at least struggle with. For instance, various pattern

[a] Corresponding author email address: pedram.mohajer@outlook.com (P. MohajerAnsari).
Available online 08/29/2023
2676-3311/BGSA Ltd.

recognition problems are examples of tasks that conventional computational methods fail to solve satisfactorily, while the brains of even the simplest animals easily handle such issues.

An Artificial Neural Network (ANN) is an idea for processing information that is inspired by the biological neural system and processes information like the brain. The key element of this idea is a novel information processing system structure. This system consists of a vast number of extraordinarily interconnected processing elements that work in coordination to solve a problem. ANNs, like humans, learn by example. An ANN is adjusted during a learning process to perform specific tasks, such as pattern recognition and data classification. In biological systems, learning is associated with adjustments in synaptic connections between nerves.

The eventual purpose for the process of learning in neural networks is to acquire the best structure of weighted edges and their bios. Such a way that the least number of errors may occur in network training and test specimens [1,2]. The reference [3] demonstrates that metaheuristic optimization methods may be substituted with gradient-based learning algorithms, since the stochastic character of these algorithms prevents them from being trapped in a local optimum, increases the convergence rate, and decreases classification errors. The first artificial neuron was built in 1943 by a neurophysiologist named Warren McCulloch and a logician named Pits Walter. However, technological limitations at the time did not allow for more extensive work on them.

On the other hand, any system that performs data classification consists of three main parts: data acquisition, feature extraction, and classifier design. The novelty of this article occurred in the feature extraction section. In general, all extracted features are not useful and may contain useless or duplicate information. Feature selection can be seen as the process of identifying useful features and removing useless and repetitive features. The goal of feature selection is to obtain a subset of features that solve problems well with minimal performance degradation. The goal of feature selection is to obtain a subset of features that solve problems well with minimal performance degradation.

This theory is mentioned here: No Free Lunch (NFL) [4,5]. This proposition demonstrates logically that no metaheuristic method exists that is capable of resolving all optimization problems. In other words, one metaheuristic technique may perform admirably and predictably on one set of issues while failing miserably on another set of problems [6,7]. NFL stimulates this field of study and contributes to the development of new methodologies and the formulation of new metaheuristic methods on an annual basis [8]. Taking into mind the described theory, the aforementioned issues, and GOA's capacity to cope with big data, this approach may be utilized to train Multilayer Perceptron Neural Networks (MLP-NN) and, subsequently, to classify sonar data [9].

2. Architectures

2.1 Human Brain

The human brain contains more than 10 billion nerve cells or neurons. On average, each neuron is connected to its surrounding neurons by about 10,000 synapses. This network structure of the brain's neurons creates a very extensive parallel information processing structure (contrasted with a personal computer that attempts to process everything using a single processor). In total, although each of the human brain's cells operates at a frequency of around 100 hertz and computer processors work at speeds in the order of megahertz, human-made processors still possess significantly lower capabilities compared to the human brain.

Striking features of the brain's neural network can be referred to as follows: 1- Graceful degradation: In these systems, the extent of the system's output degradation is directly related to the damage to the nervous system, and damage to a part of the brain does not prevent the whole from functioning properly. 2- Ability to learn and gain experience: Improves its operation using acquired experiences. 3- Performing a very large number of heavy computations in parallel. 4- Supports individual's intelligence and self-awareness. To sum up, artificial neural networks, by imitating real neural networks, strive to mimic the operation of the human brain.

2.2 Artificial Neural Networks

ANN are modern computational systems and methods for machine learning, knowledge representation, and ultimately applying the acquired knowledge to predict the output responses of complex systems. The main idea of these networks is inspired by the operation of the biological nervous system, for data processing and information for learning and knowledge creation. The key element of this idea is to create a new structure for the information processing system. This system consists of a large number of extremely interconnected processing elements called neurons that work together to solve a problem and transmit information through synapses. In these networks, if a cell is damaged, the rest of the cells can compensate for its absence and also participate in its reconstruction. These networks are capable of learning. Learning in these systems is adaptive, meaning that using examples, the weights of the synapses change in such a way that when new inputs are given, the system produces the correct response (Figure 1).

Different types of ANN

1- Multi-Layer Perceptron or MLP

2- Radial Basis Function Neural Networks or RBF

3- Support Vector Machines or SVM

4- Self-Organizing Maps or SOM

5- Learning Vector Quantization or LVQ

6- Hopfield Neural Network

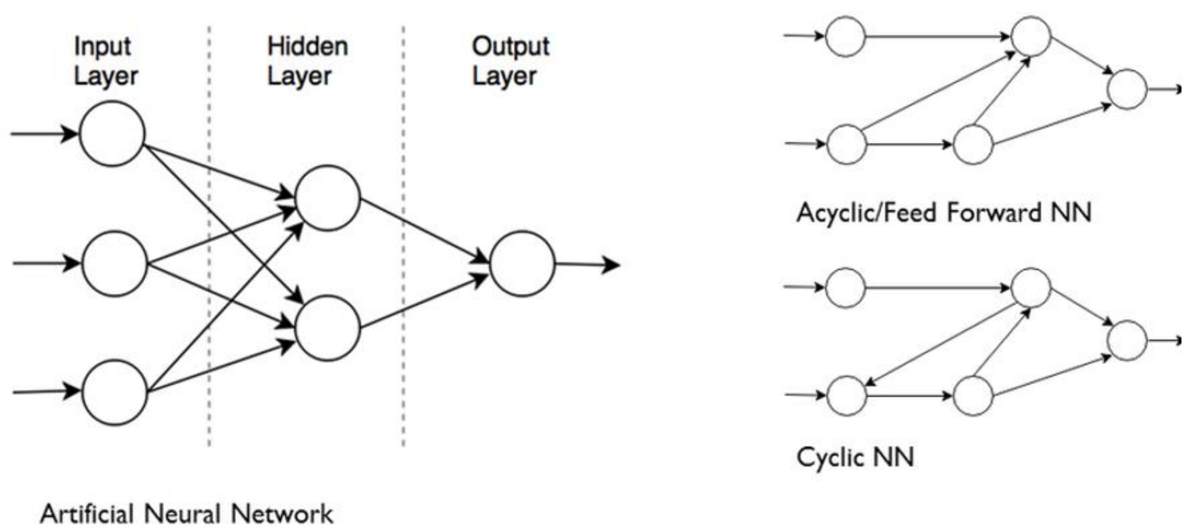

Figure 1. Artificial Neural Network.

2.3 Multi-Layer Perceptron

One of the most fundamental existing neural models is the Multi-Layer Perceptron (MLP), which simulates the transmissive functioning of the human brain. In this type of neural network, the behavior of the human brain network and the propagation of signals in it has been mostly considered. Therefore, they are sometimes also referred to as Feedforward Networks. Each of the nerve cells in the human brain, known as a neuron, after receiving an input (from another neural or non-neural cell), performs a processing on it and transfers the result to another cell (neural or non-neural). This behavior continues until a specific result is achieved, which may likely lead to a decision, processing, thought, or movement.

2.4 Radial Basis Function Neural Networks

Similar to the MLP neural network pattern, there is another type of neural network where the processing units are focused on a specific location in terms of processing. This focus is modeled through Radial Basis Functions (RBF). Structurally, RBF neural networks do not differ significantly from MLP networks, and only the type of processing that neurons perform on their inputs differs. However, RBF networks often have a faster learning and preparation process. In fact, due to the neurons' focus on a specific functional range, their adjustment will be easier.

2.5 Support Vector Machines

In MLP and RBF neural networks, the focus is often on improving the neural network structure so that the estimation error and the number of neural network mistakes are minimized. However, in a specific type of neural network, known as Support Vector Machine (SVM), the focus is solely on reducing the operational risk associated with improper performance. The structure of an SVM network has many similarities with the MLP neural network, and its main difference is in the learning method.

2.6 Self-Organizing Maps

The Kohonen neural network, or Self-Organizing Map (SOM), is a specific type of neural network that is completely different in terms of operation, structure, and application from the types of neural networks previously discussed. The main idea of self-organization mapping is inspired by the functional division of the cortical area of the brain, and its main application is in solving problems known as "unsupervised learning" problems. In fact, the main function of a SOM is to find similarities and similar categories among a plethora of data provided to it, similar to what the human brain's cortex does in classifying a plethora of sensory and motor inputs into similar groups.

2.7 Learning Vector Quantization

This specific type of neural network extends the idea of SOM neural networks to solve supervised learning problems. On the one hand, the LVQ neural network, or Learning Vector Quantization, can be described as if the MLP neural network is learning to perform a task with a different approach. The main application of this type of neural network is in solving classification problems, which covers a wide range of applications in intelligent systems.

2.8 Hopfield Neural Network (Hopfield)

This type of neural network is more akin to a dynamic system that has two or more stable equilibrium points. Starting from any initial conditions, this system eventually converges to one of its equilibrium points. Convergence to any equilibrium point is identified as recognition that the neural network has created and can indeed be used as an approach to solve classification problems. This system is one of the oldest types of neural networks with a recursive structure, and in its structure, there are internal feedbacks (Figure 2).

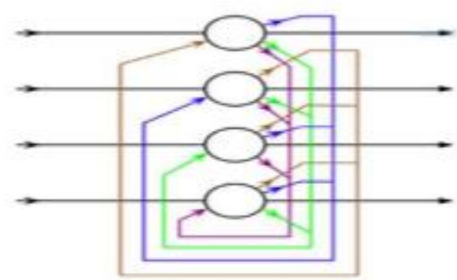

Figure 2. Hopfield neural network.

3. Advantages and limitations of the neural network

3.1 Advantages

1. Neural networks have the potential ability to solve problems that are difficult to simulate through logical reasoning, expert system analytical techniques, and standard software technologies.
2. This technique can provide a logical answer when data is under uncertainty, whether the data is fuzzy or received incomplete and accompanied by noise.

3. Due to technical advancements, it has high processing speed.
4. Neural calculators are very flexible when conditions change. Also, their maintenance is very simple.
5. Adaptive Learning: The ability to learn how to perform tasks based on information provided for training and initial experiences.
6. Self-organization: An ANN can create its own organization or presentation for the information it acquires during the learning period.
7. Real-time operation: ANN computations can be performed in parallel, and specific hardware has been designed and built that can take advantage of this feature.

3.2 Limitations

1. Neural network systems are incapable of explaining the logic and rule of operation, and proving the correctness of the results is very difficult because in many problems the adjusted weights are not interpretable. Therefore, the logic underlying the decision cannot be clarified and proven.
2. Neural network computations usually require large amounts of data for training and testing the model.
3. Generally, neural networks are not effective for certain problems. For instance, an ANN is not suitable for solving problems and processing data with a methodological approach.

4. Results and discussion

In a computer memory, to access an image, for instance, you must know its address in the memory; you can't easily find its address by having the image itself. However, the human mind functions in a way that by seeing an image, even an incomplete one, it immediately recalls the entire image, or by reading a text, it quickly brings to mind all the related content. In fact, the human mind is a type of Content-Addressable Memory (CAM). As the name suggests, in this type of memory, by providing the content of a memory cell, its address is immediately given as output.

Nowadays, there is increasing interest in the application of artificial intelligence techniques and modeling tools in business. In this regard, expert systems have gained a special place. Over the past few decades, the topics of neural networks and genetic algorithms have attracted the attention of many academics. These two are recognized and used as powerful tools in solving problems that were unsolvable by past traditional methodologies and techniques. Their use has permeated our social life to such an extent that they play a vital role in decision-making. This paper presents evidence based on the ethical use of neural networks and genetic algorithms, which leads to successful decision-making related to business problems. To this end, a comparative study of other researchers' efforts is necessary, which is done in the form of subject literature. Therefore, in our research, emphasis is placed on the role of operational researchers in the field of neural networks and genetic algorithm applications.

On the other hand, diverse applications of genetic algorithms have been presented by different individuals: multi-sided monopolistic market strategy selection, development of financial investment strategies [10], search for rules, technique for their application in the stock market [11], risk analysis in banking [12]. Furthermore, in 1999, Karejalainen and Allen used genetic algorithms to find commercial technical rules. At the same time, Andra and his colleagues (1999) used genetic algorithms in technical analysis in the Madrid stock market.

Other financial systems based on neural networks and genetic algorithms can include the following:

- KABAL - A knowledge-based system for financial analysis in banking [13].
- CREDEX - A system for credit evaluation [14].
- FINEVA- A multi-criteria knowledge-based system supporting decision-making for performance and viability assessment of a company.

Advantages of Using Artificial Intelligence Technologies by examining the consensus of existing theories and research, the benefits of using artificial intelligence technologies and genetic algorithms can be summarized in the following propositions:

- Providing better services to customers
- Reducing the time to complete tasks
- Increasing production

Neural Networks Artificial neural networks can be classified as dynamic systems that process experimental data and transfer knowledge beyond the data to the network. The neural network functions like a brain, and its nerves are similar to real nerves. Neural networks are structured in parallel. In this state, the network can learn. Neural networks are used when the structure of problems is unclear, and some kind of pattern recognition or identification needs to take place. Financial institution managers, financial institutions, and professional investors often face these situations. The steps of model design are as follows:

1- Gather all data in one place.

2- Divide the data into two groups: test data and training data.

3- Convert the data into suitable inputs for entry into the system.

4- Choose the network architecture. Train and test it. Repeat steps 1, 2, and 3 as necessary.

5. Conclusion

Neural networks process information in a way similar to the brain. Neural networks work with examples and cannot be programmed to perform a specific task. Examples must be carefully selected; otherwise, valuable time is wasted, or worse, the network may function incorrectly. The final result of these discussions points to the diversity of application areas that highlight the benefits and advantages of neural networks and genetic algorithms. These two technologies are increasingly being used as decision-making tools by organizations. The results obtained from their use, such as correct decisions, time savings, flexibility, improved quality, and effective training, have added to their popularity.

References:

[1] Adam, S. P., Alexandropoulos, S. A. N., Pardalos, P. M., & Vrahatis, M. N. (2019). No free lunch theorem: A review. Approximation and optimization: Algorithms, complexity and applications, 57-82.

[2] Bostanci, B., & Bostanci, E. (2013). An evaluation of classification algorithms using Mc Nemar's test. In Proceedings of Seventh International Conference on Bio-Inspired Computing: Theories and Applications (BIC-TA 2012) Volume 1 (pp. 15-26). Springer India.

[3] Castillo, O., & Melin, P. (2002). Hybrid intelligent systems for time series prediction using neural networks, fuzzy logic, and fractal theory. IEEE Transactions on Neural Networks, 13(6), 1395-1408.

[4] Chen,S. C.,(1991). Orthogonal least Squares Learning Algorithm for Radial Ba-aia Function Networks, IEEE Trans on Neural Networks, 302-309.

[5] Ho, Y. C., & Pepyne, D. L. (2002). Simple explanation of the no-free-lunch theorem and its implications. Journal of optimization theory and applications, 115, 549-570.

[6] Karray, F. O., & De Silva, C. W. (2004). Soft computing and intelligent systems design: theory, tools, and applications. Pearson Education.

[7] Kosarirad, H., Ghasempour Nejati, M., Saffari, A., Khishe, M., & Mohammadi, M. (2022). Feature selection and training multilayer perceptron neural networks using grasshopper optimization algorithm for design optimal classifier of big data sonar. Journal of Sensors, 2022.

[8] Kothari, R., & Agyepong, K. (1996, June). On lateral connections in feed-forward neural networks. In Proceedings of International Conference on Neural Networks (ICNN'96) (Vol. 1, pp. 13-18). IEEE.

[9] Lai, K. H., Zainuddin, Z., & Ong, P. (2017, August). A study on the performance comparison of metaheuristic algorithms on the learning of neural networks. In AIP Conference Proceedings (Vol. 1870, No. 1). AIP Publishing.

[10] Qiao, W., Liu, W., & Liu, E. (2021). A combination model based on wavelet transform for predicting the difference between monthly natural gas production and consumption of US. Energy, 235, 121216.

[11] Wang, P., Yu, X., & Lü, J. (2014). Identification and evolution of structurally dominant nodes in protein-protein interaction networks. IEEE transactions on biomedical circuits and systems, 8(1), 87-97.

[12] Wang, Y., Han, X., & Jin, S. (2023). MAP based modeling method and performance study of a task offloading scheme with time-correlated traffic and VM repair in MEC systems. Wireless Networks, 29(1), 47-68.

[13] Zhao, H., Zhu, C., Xu, X., Huang, H., & Xu, K. (2022). Learning practically feasible policies for online 3D bin packing. Science China Information Sciences, 65(1), 112105.

[14] Zheng, H., & Jin, S. (2022). A multi-source fluid queue based stochastic model of the probabilistic offloading strategy in a MEC system with multiple mobile devices and a single MEC server. International Journal of Applied Mathematics and Computer Science, 32(1).