Volume: 2 Issue: 5 Pages: 13-16


# Application of Neural Networks in Solving Business Problems

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**Article Info.**
**E-ISSN: 2583-6528**
**Impact Factor (SJIF): 5.231**
**Available online:**
**www.alladvancejournal.com**

**Received:** 18/April/2023
**Accepted:** 24/May/2023

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**Abstract**
The article discusses the application of neural networks in business and financial fields, focusing on management, marketing, and decision making. The article explains that neural networks are capable of modeling the relationships present in data collections, which makes them useful for data mining and increasing business intelligence. The article highlights the benefits of neural networks, including their ability to detect patterns that human eyes fail to perceive, and to recognize relationships and patterns in a given set of similar data. The two main types of neural networks discussed are the multilayered feedforward neural network (MFNN), used for prediction and classification problems, and the self-organizing map (SOM), used for clustering data. The architecture of MFNN and the different activation functions that can be used in the network are also explained. The article further states that artificial neural networks are based on a mathematical model that facilitates information processing and learns from data by adjusting synaptic connections. The article concludes that neural networks are special computing systems that resemble the mesh-like interconnected elements (called neurons) present in the brain, and they have emerged as one of the fastest-growing areas in artificial intelligence.

**Keywords:** Neural networks, Operations research, Business, Data mining, multilayered feedforward neural network, self-organizing map

## Introduction

During the last decade, neural networks have established themselves as a theoretically sound alternative to traditional statistical models, and a large body of research on their application to business has been produced. The comprehensive range of business and financial applications is such that a focus is required for an in-depth analysis, therefore this review addresses applications related to management, marketing and decision making.

Business data is arguably the most important asset that an organization owns. Whether the data records sales figures for the last 5 years, the loyalty of customers, or information about the impact of previous business strategies, the potential for improving the business intelligence of the organization is clear. Most businesses are now storing huge volumes of data in data warehouses, realizing the value of this information. The process of converting the data into business intelligence, however, still remains somewhat a mystery to the broader business community.

Data mining techniques such as neural networks are able to model the relationships that exist in data collections and can therefore be used for increasing business intelligence across a variety of business applications. Unfortunately, the mathematical nature of neural networks has limited their adoption by the business community, although they have been successfully used for many engineering applications for decades.

The two main types of neural networks the first is the multilayered feedforward neural network (MFNN) used for prediction problems, such as stock market prediction, and classification problems, such as classifying bank loan applicants as good or bad credit risks. The second type of neural network is the self-organizing map (SOM) used for clustering data according to similarities, finding application in market segmentation, for example. These two main neural network architectures have been used successfully for a wide range of business areas as, including retail sales, marketing, risk assessment, accounting, financial trading, business management, and manufacturing.

Neural networks are special computing systems that resemble the mesh like interconnected elements (called neurons) present in the brain. Though they resemble the human neurons they are much simpler in structure. The interconnected processors of the neural network are similar to the brain such that they have the ability to operate parallel processes and can also carry out dynamic interactions. Thus, it can learn from the data, which it has processed. Then, it recognizes the relationships and patterns in a given set of similar data.

Neural networks have emerged as one of the fastest growing areas in artificial intelligence. With the help of the neural network program, it is possible to provide capabilities in a computer system that is similar to human beings and then system is capable to recognize and classify the written characters, voices, pictures and faces. The neural networks model the human brain and are much more powerful than neurons present in human brains.

For example, they are able to detect those patterns that human eye fail to perceive. This is because a human being considers two or three variables while the neural networks detect correlations among hundreds of variables at a time. The artificial neural network (also known as neural net or neural network) is based on mathematical model that facilitates information processing, based on the connectionist approach for computation.

The Artificial Neural Network (ANN) is a computational model. The processing of information is influenced by the process of biological nervous systems. The paradigm's main element is the structure of the information process in system which has a large number of interconnected processing elements (called neurons), which work together to solve the problems. Like human beings, the ANNs also have the ability to learn by examples. The ANN needs to be configured to a particular application like data classification or pattern recognition. The ANN learns in a similar manner like biological systems, i.e., by adjusting to synaptic connections.

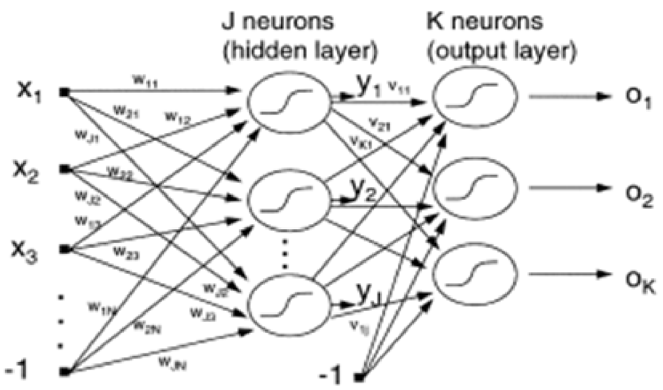


**Fig 1:** Architecture of MFNN. (Note: not all weights are shown)

MFNN (Multilayered feedforward neural networks)

A multilayer feedforward neural network is an interconnection of perceptron's in which data and calculations flow in a single direction, from the input data to the outputs. The number of layers in a neural network is the number of layers of perceptron's. The simplest neural network is one with a single input layer and an output layer of perceptron's. The network in Figure 1 illustrates this type of network. Technically, this is referred to as a one-layer feedforward network with two outputs because the output layer is the only layer with an activation calculation.

In this single-layer feedforward neural network, the network's inputs are directly connected to the output layer perceptron's, $Z_1$ and $Z_2$. The output perceptron's use activation functions, $g_1$ and $g_2$, to produce the outputs $Y_1$ and $Y_2$.

**Since**

$$Z_1 = \sum_{i=1}^{3} W_{1,i}\, x_i + \mu_1 \text{ and } Z_2 = \sum_{i=1}^{3} W_{2,i}\, x_i + \mu_2$$

$$Y_1 = g_1(Z_1) \text{ and } Y_2 = g_2(Z_2)$$

When the activation functions $g_1$ and $g_2$ are identity activation functions, the single-layer neural network is equivalent to a linear regression model. Similarly, if $g_1$ and $g_2$ are logistic activation functions, then the single-layer neural network is equivalent to logistic regression. Because of this correspondence between single-layer neural networks and linear and logistic regression, single-layer neural networks are rarely used in place of linear and logistic regression.

The next most complicated neural network is one with two layers. This extra layer is referred to as a hidden layer. In general there is no restriction on the number of hidden layers. However, it has been shown mathematically that a two-layer neural network can accurately reproduce any differentiable function, provided the number of perceptrons in the hidden layer is unlimited.

However, increasing the number of perceptrons increases the number of weights that must be estimated in the network, which in turn increases the execution time for the network. Instead of increasing the number of perceptrons in the hidden layers to improve accuracy, it is sometimes better to add additional hidden layers, which typically reduce both the total number of network weights and the computational time. However, in practice, it is uncommon to see neural networks with more than two or three hidden layers.

## Objectives

The article discusses the application of neural networks in business and financial fields, focusing on management, marketing, and decision making.

The article explains that neural networks are capable of modeling the relationships present in data collections, which makes them useful for data mining and increasing business intelligence.

There are two main types of neural networks discussed: the multilayered feedforward neural network (MFNN), used for prediction and classification problems, and the self-organizing map (SOM), used for clustering data.

## SOM

The Self-organising Map (SOM) is an unsupervised machine learning algorithm introduced by Teuvo Kohonen in the 1980s [1]. As the name suggests, the map organises itself without any instruction from others. It is a brain-inspired model. A different area of the cerebral cortex in our brain is responsible for specific activities. A sensory input like vision, hearing, smell, and taste is mapped to neurons of a corresponding cortex area via synapses in a self-organising way. It is also known that the neurons with similar output are in proximity. SOM is trained through a competitive neural network, a single-layer feed-forward network that resembles these brain mechanisms.

The SOM's algorithm is relatively simple, but there may be some confusion at first sight and difficulties figuring out how to apply it in practice. It may be because SOM can be understood from multiple perspectives. It is like Principal Component Analysis (PCA) for dimensionality reduction and visualization. SOM can also be considered a type of manifold learning that handles non-linear dimensionality reduction.

SOM is also used in data mining for its vector quantization property [2]. The train can represent high-dimensional observable data onto lower dimension latent space, typically on a 2D square grid, while preserving the topology of the original input space. But the map can also be used for projecting new data points and seeing which cluster belongs to the map, too.

This article explains the basic architecture of the Self-Organizing Map and its algorithm, focusing on its self-organizing aspect. We code SOM to solve a clustering problem using a dataset available at UCI Machine Learning Repository [3] in Python. Then we will see how the map organizes itself during the online (sequential) training. Finally, we evaluate the trained SOM and discuss its benefits and limitations. SOM is not the most popular ML technique, and it is not very often seen outside academic literature; however, it does not conclude SOM is not an effective tool for all the problems. It is relatively easy to train a model, and visualization from the trained model can be used to explain to non-technical auditors effectively. We will see that the issues faced by the algorithm are often shared among other unsupervised methods, too.

## Architecture and Working of Self-organizing Maps

Self-Organizing Maps consist of two important layers, the first one is the input layer, and the second one is the output layer, which is also known as a feature map. Each data point in the dataset recognizes itself by competing for a representation. The Self-Organizing Maps' mapping steps start from initializing the weight to vectors. After this, a random vector as the sample is selected and the mapped vectors are searched to find which weight best represents the chosen sample. Each weighted vector has neighboring weights present that are close to it. The chosen weight is then rewarded by being able to become a random sample vector. This helps the map to grow and form different shapes. Most generally, they form square or hexagonal shapes in a 2D feature space. This whole process is repeatedly performed a large number of times and more than 1000 times.

Self-Organizing Maps do not use backpropagation with SGD to update weights, this unsupervised ANN uses competitive learning to update its weights i.e Competition, Cooperation and Adaptation. Each neuron of the output layer is present with a vector with dimension n. The distance between each neuron present at the output layer and the input data is computed. The neuron with the lowest distance is termed as the most suitable fit. Updating the vector of the suitable neuron in the final process is known as adaptation, along with its neighbour in cooperation. After selecting the suitable neuron and its neighbours, we process the neuron to update. The more the distance between the neuron and the input, the more the data grows.

## To Simply Explain, Learning Occurs in the Following Ways

- Every node is examined to calculate which suitable weights are similar to the input vector. The suitable node is commonly known as the Best Matching Unit.
- The neighbourhood value of the Best Matching Unit is then calculated. The number of neighbours tends to decrease over time.
- The suitable weight is further rewarded with transitioning into more like the sample vector. The Neighbours transition like the sample vector chosen. The closer a node is to the Best Matching Unit, the more its weights get altered and the farther away the neighbour is from the node, the less it learns.
- Repeat the second step for N iterations.

## Scope of Neural Network

Neural networks are used in a number of business applications, including decision-making, pattern recognition, and sequence recognition. For example, it's possible to create a semantic profile of a person's interests from pictures used during object recognition training.

Domains that potentially stand to benefit from neural networks include banking, where AI systems can evaluate credit and loan application evaluation, fraud and risk, loan delinquencies, and attrition. On the business analytics side, neural networks can model customer behavior, purchase, and renewals and segment customers while analyzing credit line usage, loan advising, real estate appraisal, and more. Neural networks can also play a role in transportation, where they're able to power routing systems, truck brake diagnosis systems, and vehicle scheduling. And in medicine, they can perform cancer cell analysis, emergency room test advisement, and even prosthesis design. Individual companies are using neural networks in a variety of ways. LinkedIn, for instance, applies neural networks-along with linear text classifiers-to detect spam or abusive content in its feeds. The social network also uses neural nets to help understand the kinds of content shared on LinkedIn, ranging from news articles to jobs to online classes, so it can build better recommendation and search products for members and customers.

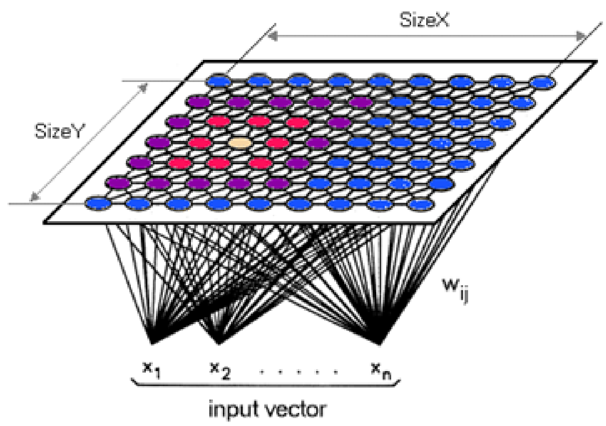


**Fig 2:** Structural model of self-organizing map neural network

Call analytics startup Dialog Tech also employs neural networks to classify inbound calls into predetermined categories or to assign a lead quality score to calls. A neural network performs these actions based on the call transcriptions and the marketing channel or keyword that drove the call. For example, if a caller who's speaking with a dental office asks to schedule an appointment, the neural network will seek, find, and classify that phrase as a conversation, providing marketers with insights into the performance of marketing initiatives. Another business among the many using neural networks is recruitment platform Untapt. The company uses a neural network trained on millions of data points and hiring decisions to match people to roles where they're more likely to succeed. "Neural nets and AI have incredible scope, and you can use them to aid human decisions in any sector. Deep learning wasn't the first solution we tested, but it's consistently outperformed the rest in predicting and improving hiring decisions," cofounder and CTO Ed Donner told Smart sheet.

**Findings**

The article explains the architecture of MFNN and the different activation functions that can be used in the network. The article also explains that artificial neural networks are based on a mathematical model that facilitates information processing, and they learn from data by adjusting synaptic connections. The article highlights the benefits of neural networks, including their ability to detect patterns that human eyes fail to perceive, and to recognize relationships and patterns in a given set of similar data.

**Conclusion**

This paper provides an overview of neural network models applicable for solving business problems. The article explains how neural networks are able to model the relationships in data collections, and can be used for increasing business intelligence in management, marketing, and decision making. The two main types of neural networks are the multilayered feedforward neural network (MFNN) and the self-organizing map (SOM). The MFNN is used for prediction and classification problems, and the SOM is used for clustering data according to similarities. The article also includes a detailed explanation of the architecture of a MFNN, and how it works.

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