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A QUALITATIVE STUDY ON THE APPLICATIONS OF ARTIFICIAL NEURAL NETWORKS IN THE BANKING SECTOR

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Abstract: Banks are institutions that play a significant role in the economy through the diverse financial products and services they offer. Given that they operate in a competitive environment, they are constantly striving to employ the best methods to withstand competition. Among the latest techniques widely adopted by banks today are various applications of artificial intelligence, with artificial neural networks being at the forefront. This paper explores the various uses of these neural networks in banks and the benefits these uses bring to the banking sector as a whole. Therefore, this study is presented as a qualitative study, relying on the descriptive approach to draw valuable conclusions on the subject by reviewing relevant previous literature closely related to the study topic. The research concluded that artificial neural networks are highly beneficial for banks as they contribute significantly to predicting various risks facing the bank, as well as providing many other advantages, which will be discovered in this paper.

Keywords: Artificial Neural Networks; Artificial Intelligence Applications; Information; Banks; Banking Risks.

Introduction

The enormous scientific and technological advancements of the last two centuries have significantly impacted the progress and development of human life across various fields, including the field of banking and everything related to its objectives, tools, and means. The major developments in computer science and telecommunications engineering, along with the rapid and successive changes currently experienced by the banking environment due to globalization and its various consequences, have made information systems management a vital activity in these banks. In their efforts to create, develop, and sustain competitive advantages, banks must adopt effective methods to manage their various operations in a way that ensures speed, accuracy, cost reduction, and the improvement of the quality of all their activities and services. In this context, the integration of modern artificial intelli-

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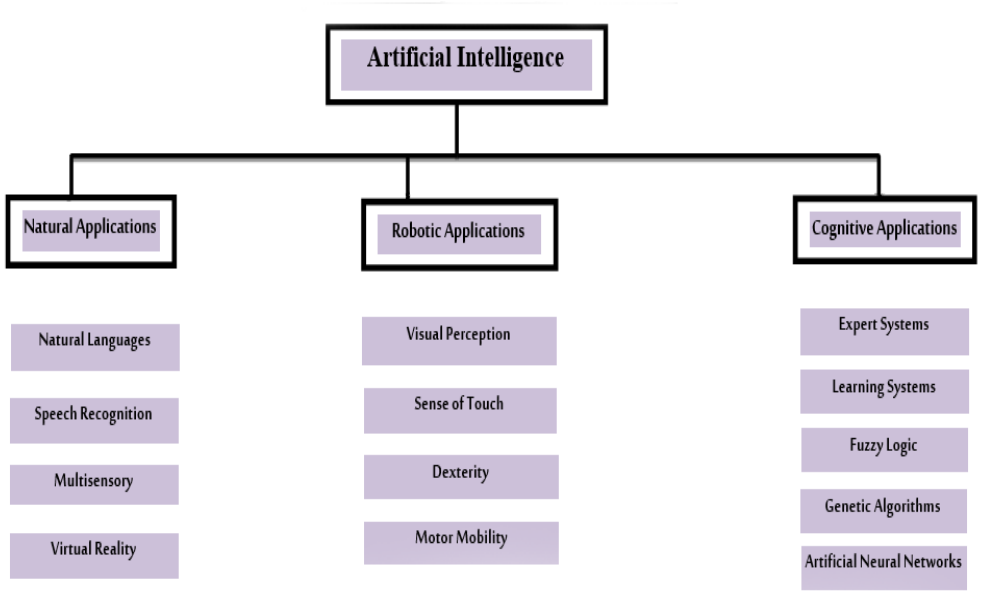
gence (AI) applications in banks emerges as an important tool for achieving competitive superiority and excellence.

Within computer science, artificial intelligence is a discipline that focuses on automating human behavior (Luger, 2009). Artificial intelligence may be defined as a scientific discipline and engineering related to understanding what is called intelligent behavior and working to embody this behavior artificially (Shapiro, 1992), enabling computers to execute tasks with a high degree of efficiency that mimics human capabilities. Machines become capable of learning, even partially, as humans do, according to McCarthy (2007: 1), who was the first to refer to the term "artificial intelligence" in 1955.

Artificial intelligence encompasses a diverse array of applications, such as expert systems, logical reasoning, gaming, Interest areas include speech recognition, human-machine interaction, natural language comprehension, multi-agent systems, planning, constraint fulfillment, computational linguistics, neural networks, and more. Knowledge representation, learning, robotics, image processing, and handwriting recognition are some of the areas of interest (Caferra, 2011: 238).

However, researchers and specialists in computer science and artificial intelligence systems have limited AI applications to three main areas: Cognitive Sciences Applications, Robotics Applications, and Natural Interface Applications, as illustrated in the following figure:

Figure (01): Basic Applications of Artificial Intelligence



Source: (O'Brien & Marakas, 2011: 422)

There is a wide variety of artificial intelligence applications, often referred to as the "family of artificial intelligence," which includes a collection of new applications across different scientific and theoretical fields. However, most researchers and specialists in artificial intelligence agree on the existence of four fundamental applications: expert systems, artificial neural networks, fuzzy logic systems, and genetic algorithms.

Among the four primary AI applications mentioned, artificial neural networks (ANNs), which are thought of as thinking models based on the human brain, will be the subject of this research. The brain of an individual is comprised of a complex and interconnected system of neurons, or basic information processing units, known as neurons. Accordingly, artificial neural networks (ANNs) are systems that represent intelligence through a network of processing elements similar to the neurons found in the brain (Graup, 2007: 22). Artificial neural networks possess a wide range of features, the most notable of which are (Haykin, 2008: 56):

– High accuracy due to the ability to simplify complex systems and handle data in parallel.
– High flexibility resulting from the capability to deal with noise in data.
– Independence from prior assumptions when analyzing data, without determining the correlations between variables.
– The ability to adapt to new information and overcome the limitations faced by classical methods.

Due to the aforementioned advantages, the use of artificial neural networks has become prevalent today in various fields, including the banking sector. This is because banks face increasingly complex challenges, as their primary material is money, which carries inherent complex risks. Additionally, the banking sector is one of the most rapidly changing sectors, especially in terms of technology. Furthermore, banks rely heavily on customer orientation and satisfaction with their services, with customer preferences being highly variable and sensitive to several other factors.

Based on this premise, the use of neural networks in banks today has become an urgent necessity due to the numerous advantages they offer to these financial institutions. This qualitative study aims to provide a comprehensive introduction to artificial neural networks and to clarify their various applications in commercial banks.

Literary Review

The literature in economics and management is rich with numerous previous studies that have addressed the topic of artificial intelligence (AI) in general. Research and studies in this area began in the 1940s with the proliferation of computers and their diverse applications. Artificial neural networks are widely recognized as one of the most notable applications of artificial intelligence, they have also garnered significant attention from researchers across various disciplines. Studies on neural networks began in the early 1950s, and since then, the topic has been enriched with a vast number of studies in fields such as medicine, engineering, science, energy, education, psychology, industry, sports, agricultural production, and human resource management, extending to the field of finance and banking. The latter has been particularly enriched with numerous studies, coinciding with the initiation of the application of artificial neural networks in banks in 1990. Since it is impossible to cover all these studies, this section will focus on some of the most prominent studies that have attempted to link artificial neural networks with their various applications in banks and financial institutions.

Study by (Fadlalla & Lin, 2001) aimed to elucidate the possibility of using artificial neural networks in the prediction of financial systems. To achieve this objective, the study was conducted as a review, the text starts with an introductory explanation of the principles behind artificial neural networks, followed by an explanation of their role in predicting stock prices, option pricing, and exchange rate forecasting. The research determined that artificial neural networks provide significant value as a forecasting tool in the field of financial economics, mostly owing to their ability to learn and generalize, and nonlinear behavior characteristics.

Another study by (Celik & Karatepe, 2007) intended to investigate how well artificial neural networks evaluate and forecast financial crises. In order to accomplish this goal, the researchers created and choose two models: one that uses artificial neural networks and operates on the same period of banking data, while the second model applies the Taguchi technique to cross-sector banking data. The study came to the conclusion that artificial neural networks may accurately analyze and forecast financial crises in addition to producing viable solutions to both structural and non-structural problems.

Study by (Eletter & Yaseen, 2010) sought to create an artificial neural network to assess loan applications in order to aid Jordanian commercial banks' loan-granting decision-making process. The researchers created a multi-application neural network that was coupled with a genetic algorithm in order to accomplish this goal. The study concluded that the neural network developed by the researchers was effective in evaluating loans in the Jordanian banking sector, making it a reliable tool for the credit-granting process in Jordanian banks.

In 2014, (Oreski, Oreski, Khan, & Ullah, 2014) offered a novel hybrid genetic algorithm (HGA-NN) that combines artificial neural networks with genetic algorithms to enhance the process

of evaluating bank loan risks. After applying this to the Croatian banking sector, the results showed that the new proposed program is highly efficient in credit risk assessment and represents a promising addition to data mining techniques.

Another study conducted by Zeinalizadeh, Shojaie, & Shariatmadari (2015) aimed to advocate for the use of artificial neural networks for the purpose of predicting customer happiness in the banking sector. To achieve this objective, a sample size of 436 customers was selected at random from 10 distinct branches of an Iranian bank to participate in the study. The data was obtained using a questionnaire that had 51 questions. The researchers used an exploratory factor analysis (EFA) to examine the variables that impact customer satisfaction, and then developed a multilayer perceptron model (ANN), in addition to relying on linear regression analysis. The results showed that the proposed neural network model was 73% more accurate than the linear regression model and revealed nine factors influencing customer satisfaction, the factors to consider are fees and loans, efficiency, aesthetics, technical capabilities, promptness, dependability, staff demeanor and behavior, bank accessibility, service accessibility, interest rates.

In the same year (Lopez-Iturriaga & Sanz, 2015), we did a research with the objective of building an artificial neural network model to forecast the insolvency of American banks, while considering the distinctive characteristics of the current financial crisis. The primary goal of this model was to predict bank failures three years before they occurred. To achieve this objective, The Federal Deposit Insurance Corporation (FDIC) provided statistics for the years 2002–2012. Using bankruptcy instances from May 2012 to December 2013, the researchers constructed their model to identify failures and evaluate banking risks in the short, medium, and long timeframes. The study concluded that the neural network proposed by the researchers was capable of detecting 96.15% of failures, outperforming traditional bankruptcy prediction results.

The same year also witnessed a study by Sharma, Govindaluri, & Balushi (2015) which explored the key determinants of online banking service users. To achieve this objective, the researchers applied a hybrid neural network regression model by integrating the Technology Acceptance Model (TAM), service quality dimensions, as well as demographic factors. Google Forms was used to gather information from 110 Omani internet bankers. The findings showed that the suggested model worked better than the basic linear regression model and determined the most important variables, which are behavior, demographics, perceived usefulness, simplicity of use, and service quality.

Meanwhile, the study by Ansari & Riasi (2016) aimed to elucidate the correlation between client loyalty and the usage of artificial neural networks, two of the most well-known uses of artificial intelligence. In order to accomplish this goal, the researchers created a survey that was sent to a sample of 389 clients of ten newly established Iranian insurance firms. The research found that artificial neural networks are an effective tool for assessing the variables that influence consumer loyalty, and that the use of this technology would be highly beneficial for emerging insurance companies aspiring to achieve competitive excellence.

More recently, a study by Yan (2022) aimed to build a new model to improve financial accounting in commercial banks. To achieve this objective, the researcher developed an enhanced model of artificial neural networks (BPNN) based on the specificity of daily financial accounting. The study concluded that the proposed model is 95.6% accurate in its results, thereby offering higher accuracy, reliability, and efficiency compared to ordinary financial accounting systems in commercial banks.

In contrast, a study by Marak, Ambarkhane, & Kulkarni (2022) intended to demonstrate a model of an artificial neural network capable of forecasting the profitability of Indian banks. Accordingly, the researchers built this model based on a set of internal and external factors affecting banking profitability. The neural network (ANN) was constructed using the cross-validation technique for predictive analysis. The study concluded that the proposed neural network provides highly accurate results in predicting the profitability of Indian banks and significantly outperforms regression models.

Methodology

This paper's primary goal is to present a comprehensive theoretical foundation for artificial neural networks' features and the range of banking applications they may be used for the focus on banking institutions is due to the significant role they play in financing various economic development activities in both industrialized and emerging nations. The importance of banking institutions continues to grow, particularly in light of the substantial developments in national economies and the profound transformations occurring in the international financial environment.

In this context, various methodological approaches were adopted to review previous literature within the framework of qualitative research. The descriptive method was employed as it is considered the most appropriate approach for studying various phenomena across different fields of social sciences, including economic and banking aspects. This method relies on studying phenomena as they exist in reality and focuses on describing them accurately. It not only involves collecting information related to the phenomenon to investigate its aspects but also extends to analysis, correlation, and interpretation to draw conclusions that enhance the body of knowledge on the subject under study.

Through this study, three fundamental research questions were examined:

– RQ1: What is meant by artificial neural networks?
– RQ2: What are the key areas of application for these artificial neural networks?
– RQ3: What are the main applications of artificial neural networks in banking?

To address these questions, a separate literature review was conducted through a rigorous systematic examination, drawing on various types of previous studies, including journals, books, conferences, dissertations, and more. Therefore, this study is exploratory research and will make significant contributions to establishing the theoretical foundations for subsequent studies.

General Framework of Artificial Neural Networks

Artificial Neural Network Definition

Artificial neural networks (ANNs) are mathematical models that are intended to replicate the composition, capabilities, and responsibilities of biological neural networks. The artificial neuron is the essential building block of any network, a rudimentary mathematical paradigm that encompasses three fundamental processes: multiplication, addition, and activation (Suzuki, 2011: 03). Some define ANNs as simplified models of the natural neural networks of the human nervous system (Hajian & Styles, 2018: 10). They are also recognized as one of the most effective artificial intelligence techniques for modeling most types of problems by relying on a set of input data. ANNs consist includes several layers of neurons that, in an effort to mimic how the human brain works, transport information and apply different algorithms from one layer to another. They lack strict rules, making them an ideal methodology for modeling random processes (Juan, Matutano, & Valdecantos, 2023: 01). ANNs are also described as a method by the human brain carries out tasks via extensive parallel processing that is dispersed across several basic processing units. These entities are computational elements known as neurons or nodes, which have neural properties, as they store practical knowledge as well by altering the weights of experiential information to make it accessible to the user. ANNs resemble the human brain in that information is stored via synaptic weights, which are the connections between neurons that strengthen knowledge acquisition through training (Kumar & Komaragiri, 2004: 144–145).

From our perspective, an artificial neural network (ANN) is a data processing system that mimics the functioning of the human brain and imitates the functioning of natural neural networks. It is built on a set of interconnected nodes called artificial neurons; these are simplified replicas of biological neurons found in the human brain. Every connection serves as a synapse between artificial neurons and is used to send impulses between them. The first step of signal processing in an artificial neuron involves receiving the signal and then transmitting it to the interconnected artificial neurons.

Function of Artificial Neural Networks

The function of ANNs can be summarized in the following stages (Khan, Ullah, Mašek, Naqvi, & Khan, 2022):

– Input Stage: The artificial neural network (j) in this stage receives input signals (xi) from nearby neurons that have been weighted by connection weights (wi). The entire input is represented by the sum of these weighted signals.

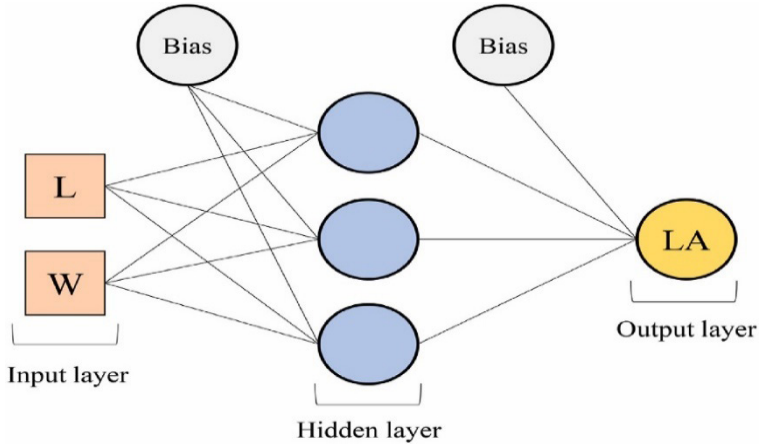
– Activation Stage: At this point, the neuron (j) receives an activation threshold, which is added to the net input and represented as a positive or negative value (yi); This is achieved by applying a mathematical function (.)f, known as the activation function, which is nonlinear.

– Output Stage: In this step, the value (yi) is calculated and sent to other neurons.

Components of Artificial Neural Networks

Three layers make up the general architecture of artificial neural networks (Figure 02): The three layers of a neural network are the input layer, the hidden stratum, and the final layer that produces the output. Artificial neurons and internal cells make up the input layer and hidden layer of a neural network, which allow the system to retrieve data from the outside world and send it to the concealed layer without changing the input data. (Ribeiro, et al., 2023: 02).

Figure (02): ANN structure with the parameters of length (L) and width (W) (input layer) and leaf area (LA) (output layer).



Source: (Ribeiro, et al., 2023: 06)

Advantages and Disadvantages of Artificial Neural Networks

This section, we will outline the most significant advantages of artificial neural networks across various fields, as well as highlight the primary disadvantages of this technology. The following table illustrates these points:

Table (1): Advantages and Disadvantages of Artificial Neural Networks

Advantages	Disadvantages
Adaptive learning on how to perform tasks based on the information provided for training and preliminary experiments.	Insufficient guidelines or directives for the creation of a network tailored to a certain application.
Ability to handle complex data.	Requires large amounts of labeled data.
Ability to model nonlinear problems.	Neural networks alone are insufficient for comprehending the physics of modeling challenges, typically, it is not feasible to establish a connection between parameters or the structure of a network and the parameters used in the processing.
Capacity for adaptation and learning.	Difficulty in predicting the network's future performance (generalization).
Ability to handle incomplete data.	Complexity and difficulty in model tuning.

Ability to extract features.	Computationally expensive and resource-intensive.
Applicability in diverse business fields.	Ethical considerations in making sensitive decisions.
Ability to handle high-dimensional data.	Difficulty in explaining results to stakeholders or interested parties.
Ability to detect hidden patterns and perform hidden analyses.	Sensitivity to the quality of data and its preparation.

Source: (Dastres & Soori, 2021)

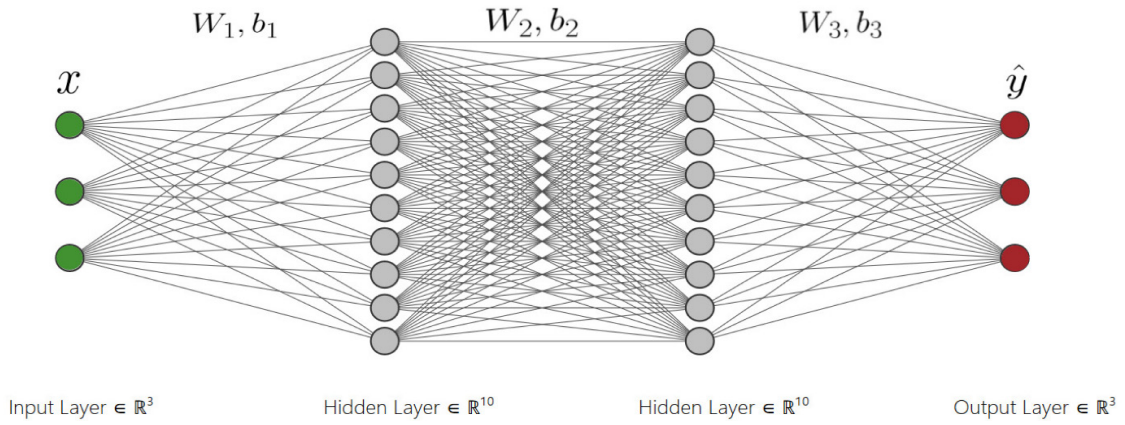
Types of Artificial Neural Networks

The structural composition of artificial neural networks is the basis for their differentiation. Therefore, we can distinguish several types, including:

A. Feedforward Neural Networks (FFNN)

Information is sent A feedforward neural network (FFNN) operates in a single direction, from the input layer to the output layer. Number of inputs and outputs is calculated without taking into account the variable's past. The artificial neural network's structure (particularly the number of hidden layers and neurons in each layer) is determined by the intricacy of the training set must be determined (Aldakheel, Satari, & Wriggers, 2021: 05). In this type of network, the signals entering the network always propagate forward, having unidirectional connection lines from the layer of input to the layer of output. Consequently, the output signal from any neuron depends solely on the input signals, as illustrated in the following figure:

Figure (03): A fully-connected feed-forward neural network



Source: (Aldakheel, Satari, & Wriggers, 2021, p. 09).

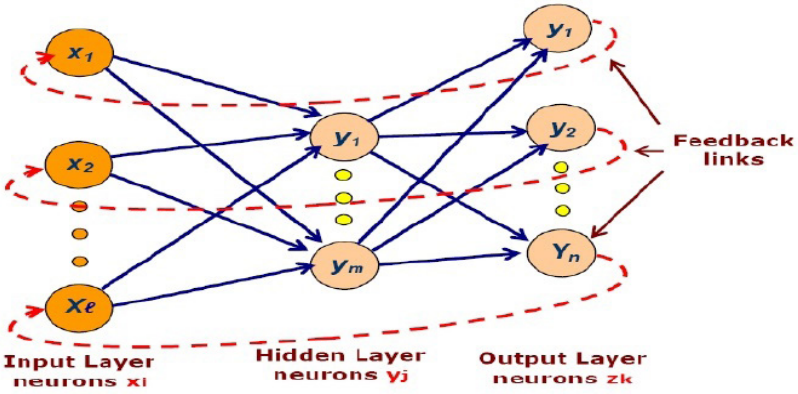
According to the above image, this fully connected feedforward artificial neural network is made up of two hidden layers, each with ten neurons, and an input layer, xxx, with three features, and an output layer y^\hat{y}y^ with three outputs.

B. Feedback Neural Networks

Also referred to as Recurrent Neural Networks, these networks are a specific sort of neural network architecture that is typically employed for the purpose of identifying patterns in sequences of data. For example, this data could be handwritten lines, texts, numerical time series, and is also applicable to images and language modeling applications, text generation, speech recognition and visual description generation, or tagging video clips (Schmidt, 2019). What sets this particular form of recurrent neural network apart is its ability to provide feedback by using all or a portion of the network's output signals, redirecting them to become input signals (feedback). Thus, the output signal from any

neuron depends on the input signals it receives as well as its previous output signals. Additionally, it contains cycles and transmits information to itself, as illustrated in figure (04).

Figure (04): Feedback Neural Networks

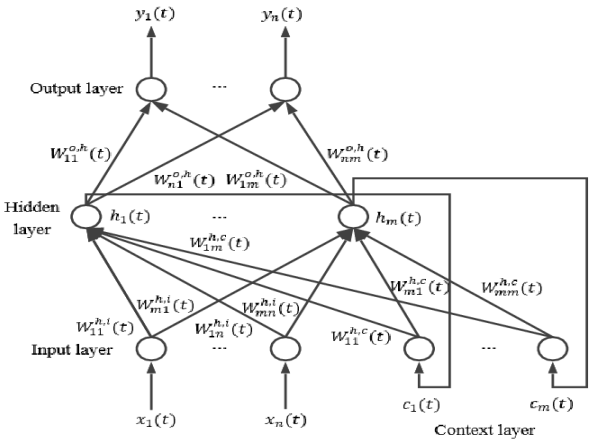


Source: (Shahid, 2018)

In this type, we can distinguish two types of feedback neural networks:

Elman Neural Network: This is a branch of neural networks (NNs) consisting of an extensive collection of neuron models organized based on specific principles. The Elman Neural Network (ENN) undergoes supervised training way utilizing the widely used backpropagation technique, using the information and desired outcomes given to the network. The four layers that comprise the system are the input layer, hidden layer, context layer, and output layer; the Elman neural network. This section is comparable to a conventional multilayer neural network and describes the interactions between the input layer, hidden layer, and output layer. These relationships may be thought of as a feedforward network. Apart from the aforementioned three layers, there is an extra layer called the context layer, whose inputs originate from the hidden layer's outputs. The context layer gets its name from the fact that it acts as a storehouse for the concealed layer's output data from the previous time step (Ren, Cao, Wen, Huang, & Zeng, Neurocomputing, 2018, p. 02). Elman networks are flexible enough to allocate a sufficient number of neurons in the hidden layers depending on the complexity of the problem. The Elman network also utilizes standard backpropagation techniques to minimize error during training (Sahoo, Satpathy, & Mohanty, 2015, p. 534). The structure of this network is illustrated in the following figure:

Figure (05): The Structure of Elman Neural Network.



Source: (Ren, Cao, Wen, Huang, & Zeng, Neurocomputing, 2018).

NARX Network – Nonlinear Autoregressive with Exogenous Input: With feedback links that shut down many network levels, A recurrent dynamic network is the NARX network. The NARX model is based on the linear ARX model, which is widely utilized in time series modeling, and is given by the following equation. (Awad, Jafar, & Osekrieh, 2017):

$$Y(t)= f(y(t-1), y(t-2),\ldots\ldots,y(t-d), x(t-1), x(t-2),\ldots\ldots,x(t-d))$$

C. Competitive Neural Networks

This type of network is also known as Clustering Nets. It discovers relationships between training patterns by clustering similar patterns into groups. Each output unit represents a cluster, and a pattern is assigned to the nearest cluster by measuring the distance between the pattern and the centers of the various clusters. The network produces a prototype vector or example for each cluster. Learning in these networks is unsupervised, which is why they are also referred to as self-organizing networks (Zaki, 2008: 167).

Applications of Artificial Neural Networks

The use of artificial neural networks has expanded significantly due to the rapid technological advancements in various areas of artificial intelligence. After reviewing numerous references on the subject of artificial neural networks, we can summarize the most important applications and uses of this technology as follows:

Science: For example, artificial neural networks can be used in pattern recognition, including handwriting and speech recognition, image processing, as well as classification tasks such as text or image classification. They can also be employed in formulating chemical compounds, modeling physical systems, evaluating ecosystems, gene recognition, plant classification, neural signal processing, biological systems analysis, and even odor analysis and identification (Li, Zhang, & Liu, 2017: 04–07).

Energy: Artificial neural networks are used in this field for predicting gas and coal prices, monitoring water dams, estimating electrical loads, forecasting energy demand, and controlling energy systems. They are also applied in measuring distorted voltage and current (Alghamdi, Abdusalam, Anayi, & Packianather, 2023: 02).

Education: For instance, this technology can be used to predict student performance, teach natural neural networks, and conduct research in this area (Chavez, Chavez-Arias, Rosas, Rodríguez, & Raymundo, 2023).

Medicine: Artificial neural networks can be utilized to develop new treatments for neurological disorders. For example, they have been used to create more accurate models for brain diseases such as Alzheimer's disease, which can lead to the development of new treatments for these conditions (Kanwisher, Khosla, & Dobs, 202: 241).

Data Processing: Among the solutions and services offered by artificial neural networks in this field are time series analysis, modeling, knowledge discovery, detecting changes and anomalies in data, data classification, and forecasting (Funes, Allouche, Beltrán, & Jiménez, 2015).

Finance and Sales: The primary uses of this technology in this domain include price and economic indicator forecasting, property valuation, fraud detection, creditworthiness assessment and credit rating, predicting market trends and bankruptcy, sales forecasting, retail margins, targeted marketing, and service usage prediction (Sharma & Chopra, 2013: 35).

Industry: Applications include process monitoring, quality control in the food industry, predicting product temperature during solar food drying, and more (Guiné, 2019: 17).

Human Resources and Operations Management: These applications include employee scheduling and classification, employee retention, recruitment and selection, operations scheduling, managerial decision-making, cash flow forecasting, employee performance, job satisfaction, and more (Rahmanidoust & Zheng, 2019).

Other Fields: These include game development, quantitative weather forecasting, sports betting, agricultural production estimates, and predicting horse race outcomes (Topczewska & Kwater, 2020: 01).

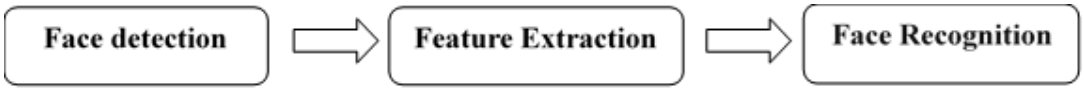
Applications of Artificial Neural Networks in Banking

Artificial neural networks in banking encompass a wide range of important applications that enhance financial services and improve operational efficiency. Below, we will outline some of these applications:

Artificial Neural Networks and Their Function in Predicting Money Laundering: Both artificial neural networks and machine learning algorithms are relatively effective in recognizing and describing money laundering transactions, at the very least. These neural networks also allow for comprehensive monitoring and auditing of factors such as time, day, and the inflow and outflow of cash may be monitored using regulatory technologies. Additional aspects that these networks may constantly monitor include foreign payments, sudden changes in income sources, significant changes in transfer amounts, and any other questionable conduct that needs to be looked at right away (Lokanan, 2022: 29). However, a significant limitation of artificial neural networks in detecting money laundering cases is the enormous amount of information required regarding customer transactions, which is often inaccessible owing to privacy restrictions or the absence of a well-organized data architecture or data cleaning process inside the institution (Rocha-Salazar, Segovia-Vargas, & Camacho-Miñano, 2021: 11). To overcome these limitations, Fuzzy neural networks – a hybrid of artificial neural networks and fuzzy logic—have been used more often as nonlinear estimating tools in recent years. Numerous benefits arise from this combination in terms of prediction, classification, clustering, and optimization methods (Heidarinia, Harounabadi, & Sadeghzadeh, 2014: 35).

Facial Recognition in Smart Banking Systems Using Artificial Neural Networks: Recently, studies have recently placed a growing emphasis on the identification of face features, as it is the most important characteristic that can be used to identify a person, particularly in the banking sector. Therefore, a system for detecting and recognizing human faces based on facial features is essential. Among these systems, artificial neural networks have become widely used for facial recognition by learning the correct classification of features calculated by the original face algorithm. The network undergoes initial training using photos from a face database, after which it is used to identify the provided face images (Jamil, Iqbal, & Iqbal, 2001). This process involves three steps, as illustrated in figure (06). The initial phase is face detection, where the computer searches the input image for an object resembling a face. The goal of face detection is to determine whether a face is present in the image, and if it is, the output will indicate its location and size. Subsequently, the subsequent course of action is identifying and extracting distinct face attributes, such as the chin, ears, eyebrows, eyes, nose, and lips. During the last stage, the outcome is cross-referenced with the database in order to ascertain the identity of the individual's face (Jatain & Jailia, 2023: 269).

Figure (06): Process in Face Recognition



Source: (Jatain & Jailia, 2023: 270)

Predicting Customer Attrition in Banking Using Artificial Neural Networks: Artificial neural network models are highly effective in predicting customer attrition in the banking industry, which leads to revenue loss and reduced customer loyalty. The prediction relies on input features and the independent variable of the dataset trained using machine learning techniques to increase customer retention and reduce churn. This technique also enables banks to identify clients who are at danger of attrition and implement proactive actions to keep them (Baby, Dawod, & Sharif, 2023).

Using artificial neural networks to predict financial distress in banks: is one way that artificial neural networks may be used as a methodology for predicting financial distress and short-term financial problems faced by banks through various variables. For instance, traditional financial variables can be used according to the CAMELS system (Capital, Assets, Management, Earnings, Liquidity, and Sensitivity), along with a series of macroeconomic variables related to banks. Artificial neural networks are very appropriate for analyzing financial distress in credit institutions, as well as bankruptcy and other financial issues affecting the sustainability of these institutions (Paule-Vianez, Gutiérrez-Fernández, & Coca-Pérez, 2020).

Utilizing Artificial Neural Networks to Identify Critical Cloud Security Risks in the Banking Sector: Artificial neural networks (ANNs) may be implemented by cloud financial service developers and IT administrators to predict critical security issues in cloud computing within the banking sector. Positive forecasts about significant cloud security concerns may improve the efficiency of cloud banking and cloud banking services (Velmurugan, Kumar, Saravanan, Patnaik, & Ikkurthi, 2023).

Improving Customer Satisfaction in Banks Using Artificial Neural Networks: Artificial neural networks play a significant role in enhancing customer satisfaction in banks. These networks rely on artificial intelligence techniques to analyze data and predict customer satisfaction levels based on multiple factors such as fees and loans, fast service, appearance, technological services, responsiveness, trust, employee behavior, ease of access to the bank, service availability, and the personalization of offers and services. Neural networks analyze data to provide personalized recommendations for each customer based on their history and interests, thereby enhancing the customer's sense of appreciation and care (Zeinalizadeh, Shojaie, & Shariatmadari, 2015).

3. Conclusion

This study stems from the significant advantages that artificial neural networks (ANNs) offer across various fields, particularly their ability to facilitate access to data and information at any time and from any location. Moreover, ANNs enable the application of human expertise and knowledge to computer programs, which can then be transferred to end-users through these networks. These features allow for the seamless adaptation to updates and developments in international standards with efficiency.

Although this research paper primarily takes a theoretical approach, it highlights several crucial points that form the foundation for serious consideration of how ANNs and their applications can support the competitive capabilities of banks, especially at a time when artificial intelligence (AI) presents itself as one of the most significant challenges for bank management.

In conclusion, it is important to note that despite the numerous advantages offered by ANNs when applied in the financial and banking sector, there are several challenges associated with their design and the appropriate method for selecting their structure. Currently, there is no established theory for determining the optimal structure, include factors such as the quantity of concealed layers and neurons, which still largely relies on intuition. Thus, their efficiency is closely tied to the user's experience. Therefore, the use of ANNs in the banking and financial sector requires careful implementation and supervision to manage the potential risks associated with this application.

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