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Artificial Neural Networks and Its Application in Various Fields of Study

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ABSTRACT

Artificial Neural Networks (ANN) approach is an alternate way to classical methods. As a computation and learning paradigm, the approach is used to solve complicated practical problems in numerous fields, such as accounting and business, engineering, medical and healthcare, geological and energy. The application varies from modelling, identification, prediction, and forecasting. In contrast to conventional procedure, ANN is trained using data exemplifying the behaviour of a system. This paper presents applications of ANN in various fields of study. The applications are in the form of designing and modelling, identification and evaluation, and prediction and control. Published literature presented in this study serves as evidence that ANN is a useful tool in various disciplines across many industries. This paper will encourage researchers and professionals to explore ANN.

Keywords: *Artificial Neural Network, prediction, forecasting, modelling*

1.0 INTRODUCTION

Artificial Neural Networks (ANN) was first introduced by Frank Rosenblatt in 1958. It is called the Perceptron model, a simple model of the biological neuron

in ANN. ANN is a processing system, motivated by the biological human brain system. It has a similar function to basic units of the human nervous system that are called “neurons”. Each neuron is associated with another neuron which carries weights. ANN consists of many nodes and connecting synapses; each node operates in parallel and connects over the connecting synapses, as shown in Figure 1. For example, the inductive learning process finds out the weights so that the relationship between input and output variables is determined. ANN is trained with examples of datasets without requiring analytical solutions. ANN learns the patterns presented to it. The methods in the process of learning are strictly related to the recommended mathematical form describing the artificial neuron function known as the activation functions. In other words, activation functions are the transfer function of an artificial neuron (Poznyak, Chairez, & Poznyak, 2019). Once they understand the pattern, new patterns may be presented to them for prediction or classification.

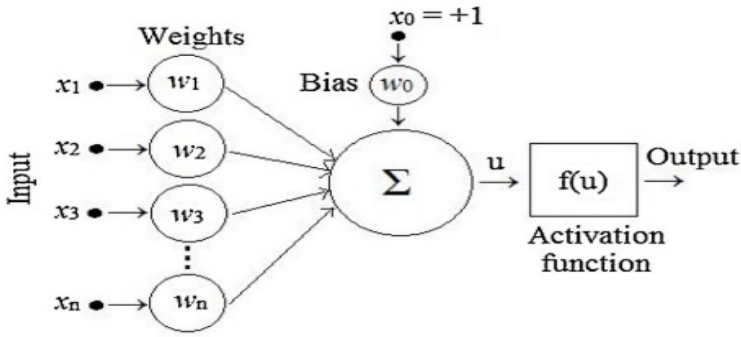

Figure 1: Mathematical model for Artificial Neural Network
Source: de Souza et al. (2019)

1.1.Categories of Artificial Neural Networks

ANN methods are categorized into two which are supervised learning and unsupervised learning (Rezaei, Shokouhyar, & Zandieh, 2019). These methods are different in terms of the data label. Under supervised learning, training data sets are labelled as training algorithms will work to find a mapping function from input and output layers. In contrast, no data label under the unsupervised learning category as it requires training data sets to find the hidden relationships in the patterns inside data set provided.

1.2. Operationalization of Artificial Neural Networks

ANN runs with training algorithms and there are numerous algorithms available for training neural network models. The training algorithms are regarded as a straightforward application of optimization theory and statistical estimation. Figure 2 shows the schematic diagram of a multilayer feed-forward neural network. The network consists of three layers: input layer, hidden layer, and output layer. Basic processing elements of ANN are represented by the number of neurons on each layer. The neurons relate to each other and each connection has an associated weight. Input layer works to feed raw information to hidden layers. At this stage, the input layer provides information for the hidden layer to learn the pattern of the input layer. Simultaneously, the hidden layer calculates the total weighted activation of other neurons through its incoming connections. Then the weighted sum is handed through an activation function and this activated value based on the input and hidden layers become the output of the neuron. According to Poznyak et al. (2019), there are four basic activation functions in ANN namely which are Threshold, Sigmoid, Piecewise and Gaussian. These functions are used in different applications in ANN. Naidu and Govinda (2018) stated that the speciality of ANN of its capability to consider the past experiences then makes a more precise decision over time. The performance of ANN relies on the mathematical function for each neuron and the weight for each interconnected neuron. The output of the neuron is obtained after the input value passed through an activation function.

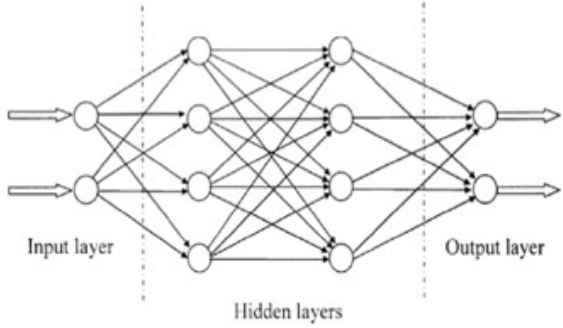

Figure 2: Schematic diagram of a multilayer feed-forward neural networks
Source: Kalogirou (2001)

The most widespread algorithm is the backpropagation algorithm, which uses a supervised learning method and a feedforward network. In the backpropagation algorithm, the weights of the neurons are defined first and then allocated to the knots. Then the learning samples are introduced into the model. The output is

then generated and compared with trial samples. An ANN with a back-propagation algorithm learns by altering the connection weights, and the alterations are stored as knowledge. Figure 3 shows an artificial neural network structure employing the back-propagation learning rule.

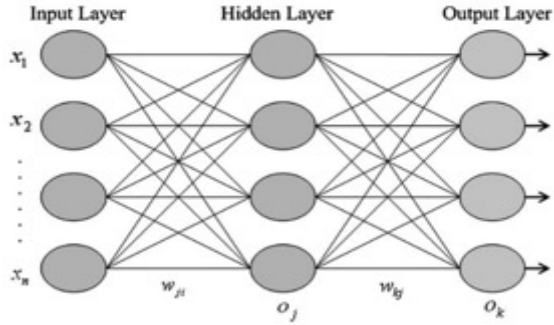

Figure 3: An artificial neural network structure employing the back-propagation learning rule
Source: Chen and Du (2009)

1.3 Advantages of Artificial Neural Networks

Empirical studies suggest that ANN provides better results mainly due to its speed and simplicity. Among the benefits are ANN can extract the nonlinear relationships by training the data and it has the potential to make better, quicker, and more practical predictions than other traditional methods (Kalogirou, 2001). ANN is also able to establish patterns, detect complicated trends, perform other computational techniques (Adebayo, Hashim, Abdan, Hanafi, & Zude-Sasse, 2017), able to solve high complexity problems (de Souza et al., 2019). Besides, ANN is sensitive to the distribution of input data as compared to other computational patterns (Jahangir, Mousavi Reineh, & Abolghasemi, 2019).

Many experts are in favour of ANN as a predicting model due to three (3) general advantages of ANN. First, ANN does not require any assumptions, hence allow inference from historical data to forecasting activity. Second, ANN can solve complex nonlinear problems. Third, ANN picks proper weights while in the training process and learns them to estimate the output, in contrast to the traditional statistical techniques that estimate the coefficient of independent variables. The ability of ANN to establish results from data it gathered during the learning process has successfully made ANN a very worthwhile tool in classification tasks (Adebayo et al., 2017). Another study by Rezaei et al. (2019) regarded ANN with efficiency, robustness, adaptability, and high performance, which turn it into a powerful tool for prediction, classification, decision support, financial analysis, and modelling in

most industries.

Despite the continuous effort on the studies in this general idea since 1958, this study attempts to translate the literature findings into a review of knowledge. This study aims to explore the existing literature regarding the ANN concept and how it benefits different disciplines. This study seeks to improve the level of understanding of how ANN is pursued at performing its function in speeding and simplifying a prediction, classification process as well as a problem-solving solution.

2.0 METHODOLOGY

This study performed a string search related to the use of ANN from peer-reviewed research databases, Web of Science and Elsevier. The keywords used to search for literature include ANN usage, ANN adoption, ANN implementation, ANN prediction, forecasting and modelling. A string search, for example, "Adopt*" OR "Artificial neural network" OR "ANN" AND "accounting" were used. These search strings were identified progressively from basic to complex terms. The exploration of related works, which are limited to publications in English, was executed from 2015 to 2019. The selected research works are the ones that consider ANN solely as the decision tool, combine ANN with other methods and associate the performance of ANN with other statistical methods. The results were organized in Microsoft Excel to ensure reliable and sufficient information are gathered as well as to identify further keywords in this study. This study identified seven different fields adopting ANN namely accounting, business, engineering, geological, medical, agriculture and energy. Several themes are performed such as the collection of definitions and concepts regarding ANN, how it works and its advantages. The abstracts were classified based on the narrative descriptions of the study. Articles were reviewed according to their field of studies to find consistency and comparisons.

3.0 APPLICATION OF ARTIFICIAL NEURAL NETWORKS IN PREVIOUS STUDIES

The application of ANN can be found in diverse fields of study and those presented in this paper are exhaustive. In the area of accounting, Naidu and Govinda (2018) used ANN to examine bankruptcy prediction and found that errors in the results using neural networks with sigmoidal activation function were lesser at 4.43% in contrast to results obtained from random forest classification at 5.19%. They concluded that neural networks are more reliable in predicting the bankruptcy of

a company. Vaez and Banafi (2017) employed a backwards propagation algorithm in ANN to predict related party transactions of companies listed in Tehran Stock Exchange. They presented that ANN models provide more than 70% coefficient of determination, which is best for prediction. ANN is also applied in a fraud prediction study. Omar, Johari and Smith (2017) reported that ANN methods outperform (94.87%) other statistical methods such as traditional statistics, linear regression and other techniques that were used in previous studies on fraudulent financial reporting prediction. Geng, Bose and Chen (2015) examined financial distress companies based on several financial ratios: net profit margin on total assets, return on total assets (ROA), earnings per share (EPS), and cash flow per share. They reported that ANN methods are better in predicting financial distress firms as compared to decision trees, support vector machines and groups of multiple classifiers. Application of ANN found in business studies was on decision support, stock price forecasting and towards classification tasks (Tkáč & Verner, 2016). Focusing on downstream lines, Rezaei et al. (2019) used ANN to establish a model to assess risk and classify the retailers who have interconnected rules downstream of the supply chain. In a broader context of supply chain management, Lima-Junior and Carpinetti (2019) proposed a model to predict systems for supply chain performance assessment. The diagnosis of the performance will result in plans and objectives improvement which will then trigger rational decision making. They used a combination of ANN and SCOR® (Supply Chain Operations Reference) metrics. It was claimed that ANN has more advantage than SCOR® metrics because it allows specific environment adaptation of historical performance data, in which applying SCOR® alone to predict supply chain performance is limited.

In the engineering field, Taheri, Abbasi and Khaki Jamei (2019) compared the application of Artificial Neural Network (ANN) and Finite Volume Method (FVM) to compute the length development of laminar magnetohydrodynamics (MHD) flow in the entrance region of a channel. The investigation of MHD flow in the channel or pipe is essential for the application in engineering sectors, taking the cooling process of reactors, design, and analysis of pipe flow systems and MHD wind tunnels as examples. The study suggested that ANN is useful in developing MHD channel flow and prediction of the development length. Xu et al. (2019) introduced a modified ABC (ABC- ISB) optimization algorithm to automatically train the parameters of Feed-Forward Artificial Neural Networks, which is a typical neural network for deep learning. They stated that deep learning has been widely used in many areas such as speech recognition, image recognition, and natural speech processing. The results of the proposed algorithm have achieved satisfactory results which means evolutionary algorithms can be used as an effective tool to optimize neural network parameters.

In geological discipline, Jahangir et al. (2019) investigated the use of ANN to improve the proposed analysis on one of Iran's natural disasters which is the flood. They used data from Hydrometric and Rain-Gauge stations, satellite images and thematic data layers in the form of ANN algorithm for prediction of discharge values and to model spatial modelling of floods at Kan River Basin located in Tehran province. The results of the study show that the ANN method has one of the highest correlations and lowest RMSE in flood modelling. Precision parameters such as R2, RMSE and MAE were used to show the efficiency of the proposed model. The current evidence can be applied in future planning to improve risk management and environmental crises. Tian, Xu, Cai, Wang and Wang (2019) proposed the use of ANN in predicting volcanic dissolution distribution using a real case study from Junggar Basin in northwestern China. The study constructed a multi-layer ANN model to map the seismic attributes into a synthetic reservoir property called Dissolution Comprehensive Values (DCV). The results of the study are like the prediction from the geological volcanic dissolution model in geological knowledge. The result proves that ANN is a reliable method to predict spatial dissolution distribution in the volcanic weathered crust. Apart from flood and volcanic crises, landslides are another natural disaster that can harm socio-economic and environment. Abbaszadeh Shahri, Spross, Johansson and Larsson (2019) developed a map on landslide susceptibility in Sweden. They used 14 causal factors to relate to landslides in a large area in Southwest Sweden. The study which captured 242 landslide events resulted in a map on landslide susceptibility which is consistent for future landslide susceptibility zonation. Interestingly, models produced based on the ANN method are cost-effective and beneficial for planning on the development of cities and municipalities in urban areas.

Penetrating medical and healthcare studies, Oner, Turan, Oner, Secgin and Sahin (2019) observed that ANN gives a higher success rate in sex identification on skeleton than the ones achieved using linear models. DNA test may be the best method to predict sex, but it has a few limitations such as costly, difficult to access, requires qualified personnel, and in some cases, DNA test failed. ANN also has been used in the development of a tool known as Fall Detection Systems (FDS); this is to assist elderly citizens from Fear of Falling (FOF) syndrome. FDS is a wearable system proposed to attach mobility sensors (especially accelerometers) to the clothes or garments transported by the subject. Unlike FDS, CAS is strategically arranged at fixed positions on a monitoring zone where patient's movements will be supervised. One of the main advantages of using ANN as the core of FDS is neural systems can directly employ the raw sensor data to produce the classification decision without requiring any further preprocessing (Casilari-Pérez & García-Lagos, 2019). However, Khojasteh, Villar, Chira, González and de la Cal (2018)

used several different models on the wrist wearable accelerometer and found that rule-based systems represent a promising research line as they perform similarly to neural networks, but with a reduced computational cost.

A Brazil study on agriculture sector performed by de Souza et al. (2019) showed that ANN models can forecast the period of banana harvesting related to five years of data are given different conditions for the climate. Adebayo et al. (2017) investigated the technology to measure the quality of bananas called Laser Light Backscattering Imaging (LLBI). Using ANN techniques, the study measured the ripening stage of a subgroup of cavendish bananas in Germany and established the quality of the banana. Bonini Neto, Bonini, Bisi, Coletta and Dos Reis (2017) used ANN to classify and analyze degraded soils which are classified as Oxisol. The study proved that ANN models produce a low mean square error from the data, suggesting that ANN can be used as a measurement tool to classify degraded soils.

In energy and environmental studies, ANN has developed many techniques and approaches that are beneficial to solve complicated system problems in wind energy systems (Kalogirou, 2001). D'Amico, Ciulla, Traverso, Lo Brano and Palumbo (2019) used ANN to solve the energy and environmental balance of buildings in Europe. They suggested that their results can be implemented in a software program in the form of software algorithms to predict a building's performance. A summary of these studies is presented in Table 1.

Table 1: ANN application in previous studies

	Authors	Field & Types of investigations	Types of training algorithms	Activation Function	Objectives	Results
1.	Naidu and Govinda (2018)	Accounting Bankruptcy predictions	ANN and Random Forest algorithms	Sigmoid function	To determine which types of training algorithms used for predicting bankruptcy of a company.	Neural network is more reliable in predicting the bankruptcy of a company.
2.	Vaez and Banafi, (2017)	Accounting Bankruptcy predictions	Backward Propagation algorithm	Tangent sigmoid transfer, linear transfer function	To predict the amount of transactions with related parties in companies listed in the Tehran Stock Exchange.	Result model the best network to predict the amount of transactions with related people.
3.	Geng et al. (2015)	Accounting Bankruptcy predictions	Prune algorithm	Not informed	To predict bankruptcy in China using ANN, decision trees and support vector machines.	Result from ANN is more accurate than other classifiers.
4.	Rezaei et al. (2019)	Business Retailer risk assessment	Batch Training algorithm	Gaussian function	To assess the risk of retailers using ANN.	A model from this study can provide a basis for classification of retailers based on the specified risk levels.
5.	Lima-Junior & Carpinetti (2019)	Business Supply chain performance	Multi-Layer Perceptron (MLP)	Logistic function, hyperbolic tangent	To propose a performance prediction system based on the SCOR® metrics using ANN.	MLP networks are adequate to support supply chains based on the SCOR® model.
6.	Taheri et al. (2019)	Engineering Computing the development length of laminar magnetohydrodynamic	Feed-Forward, Back-Propagation neural network and Levenberg Marquardt (LM) algorithm	Sigmoid Function	To study the field of the MHD flow in the entrance region and propose a correlation for	ANN can be employed for modelling the MHD channel flow and prediction of the development length.

7.	Xu et al. (2019)	Engineering Deep learning	Artificial Bee Colony (ABC)-ISB algorithm	Fitness Function	To propose a modified ABC algorithm to train the Feed-Forward Artificial Neural Net-works.	In the scout bee phase, this paper introduces an improved strategy which enhances the global search ability more effectively.
8.	Jahangir et al. (2019)	Geological Prediction of discharge values and spatial modelling of floods	Back Propagation	Nonlinear sigmoid function	To assess whether artificial neural networks can be combined with GIS spatial analysis functions for spatial modelling of the flood.	ANN method has one of the highest correlations and lowest RMSE in flood modelling.
9.	Tian et al. (2019)	Geological Prediction of volcanic dissolution distribution	Back Propagation	Rectified linear unit	To model and predict the volcanic dissolution distribution by integrating the image logging semi-quantitative analysis with seismic prediction using ANN.	Spatial dissolution distribution in volcanic weathered crust can be reliably predicted by this integrated method.
10.	Abbaszadeh Shahri et al. (2019)	Geological Identificatio n/modelling a landslide susceptibilit y	Back Propagation	Hyperbolic tangent, soft axon, squash	To produce a landslide susceptibility map.	A model on a landslide susceptibility map using ANN approach is produced.
11.	Oner et al. (2019)	Medical Identificatio n of sex	Multilayer Perceptron Classifier (MLPC)	Hyperbolic tangent	To identify sex from skeleton.	The success rates that were achieved in sex identification with measurements on the skeleton using ANN were observed to be higher than those achieved

12.	Khojasteh et al. (2018)	Medical Improving fall detection	Feed Forward	Fitness Function	To develop a wrist wearable solution for Fall Detection (FD) focused on the elderly.	The rule-based systems represent a promising research line as they perform similarly to neural networks, but with a reduced computational cost.
13.	de Souza et al. (2019)	Agriculture Modelling harvesting period of banana	Back Propagation	Hyperbolic tangent function	To predict the time of the banana harvesting period based on the relationship of climate in the banana growth.	The model of harvesting period is developed.
14.	Adebayo et al. (2017)	Agriculture Measuring stage of ripe banana	Back Propagation – Multilayer Perceptron (BP-MLP)	Sigmoid activation function	To predict and classify models of ripe bananas.	The used of LLBI together with ANN is to determine quality of banana by non-destructive estimation and classification of the banana ripeness
15.	Bonini Neto et al. (2017)	Agriculture Classification and Analysis of degraded soils	Back Propagation	Sigmoid activation function	To evaluate ANN to establish a classification and analysis of degraded soils.	ANN is interesting and powerful tool to classify degraded soils.
16.	D'Amico et al. (2019)	Energy Building energy performance	Feed-Forward BP neural network	Tanh-sigmoid activation function and a linear activation function	To propose an application of ANN to solve the energy and environmental balance of building.	ANN solves the energy and environmental balance of building.

5.0 CONCLUSION

ANN is applicable in many research fields such as accounting and business, medical and health, engineering, geological and tourism. Many researchers take the advantage of ANN as it is a fast and accurate method as well as its ability to produce multiple predictions and to work with missing parameters. However,

in the selection of training dataset for the ANN algorithms, precautions need to be taken into considerations. The review of this paper is useful for researchers and professionals to further explore ANN and consider using it as additional data analysis within their area of interest.

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