Neural Networks And Machine Learning

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2023 IEEE 5th International Conference on Cybernetics, Cognition and Machine Learning Applications (ICCCMLA) | 979-8-3503-3828-7/23/$31.00 ©2023 IEEE | DOI: 10.1109/ICCCMLA58983.2023.10346612

***Abstract*—Recent years have seen an increase in the popularity of neural network (NN) research. The mammalian brain, which consists of billions of interconnected neurons, is renowned for its ability to perform computationally hard tasks, such as face recognition, body motion planning, and muscle activity control. In an effort to emulate the effectiveness of biological neural networks in learning, artificial neural networks (ANNs) were developed. The NN technique has been the topic of many studies over the last few decades, with applications in many fields including control engineering, automation, aerospace, psychology, economics, healthcare, and energy science. The objective of the discipline of machine learning is to create computers that can independently learn and improve. In this chapter, we have attempted to depict the types of neural networks and machine learning as well as their applications in different industrial disciplines such as science, commerce, and medicine.**

Keywords— Neural Network, Machine Learning, Artificial Intelligence.

I. INTRODUCTION

In addition to classification, clustering, pattern recognition, and prediction, artificial neural networks (ANNs) have recently become popular and successful models for these tasks. In recent years, ANNs and other forms of ML models have become competitive in terms of usefulness with classic statistical and regression models. AI (machine learning, CNN, deep learning, robots), cybersecurity, big data, cloud services, the internet, and forensic science are current ICT hotspots and fascinating challenges. Precision, processing speed, latency, performance, fault tolerance, volume, scalability, and convergence may be utilised to evaluate the complete applicability of ANNs in the context of data analysis. Large-scale parallel implementation of ANNs enables high-speed processing, which drives the demand for research in this field. Artificial neural networks (ANNs) are adaptable computational tools with many uses. Due to their improved awareness, adaptability, fault tolerance, nonlinearity, and input-to-output mapping, ANNs are increasingly commonly used in mathematical paradigms to approximate global functions [1].

The objective of a neural network, which is simply a set of algorithms, is to identify data patterns in a way akin to how the human brain operates. Neural networks in this sense may refer to biological or synthetic networks of neurons. Since neural networks are adaptable, they can offer the optimal conclusion despite varying inputs. The application of neural networks, a concept with AI roots, is rapidly gaining traction in the development of trading systems [2].

Several approaches come under the machine learning (ML) umbrella for making intelligent predictions from a dataset. These datasets may include millions of individual data points, indicating their size. Recent advances in machine learning have enabled systems that seem to be on par with humans in terms of semantic understanding and information extraction and sometimes have the ability to recognise abstract patterns with more precision than human experts. Due to the needs of web-based organisations and the exponential increase in data, processing power, and algorithm creation, machine learning has evolved into a powerful tool, augmenting conventional methods for statistical modelling [3].

II. NEURAL NEWORKS

Artificial neural networks (ANNs) or simulated neural networks (SNNs) are the foundation of deep learning and an area of machine learning. Artificial neural networks are often used by major machine learning techniques in an attempt to simulate how biological organisms learn. Neurons are the cells that comprise the nervous system. The synapses, which are the connectors between the axons and dendrites, enable neurons to interact with one another. Synaptic connection strengths are dynamic and subject to change in response to environmental signals. Using specialized processing nodes called neurons, artificial neural networks simulate this natural process. Machine learning tasks that are comparable to those performed by humans may be accomplished using neural networks, which model their computer units after human neurons. The ultimate objective of neural networks is to produce artificial intelligence by designing and creating computing systems that replicate the human nervous system [4]. Compared to standard computing techniques, the innovative approach reduces more progressively during moments of high demand. The technology sector anticipates these biologically inspired techniques to be the next big thing. Computer neurons learn by observation. They cannot be instructed because they lack intellect. To prevent wasting time or, worse, causing the network to fail, it is vital to analyse the to-be-used instances thoroughly. Currently, neural networks are nothing more than a random assortment of extremely primitive artificial neurons. The layers that emerge as a result of this clustering are subsequently linked. Each neuron in a traditional network's hidden layer receives information from the neurons in the layer above it, which is often the input layer. When a neuron analyses an input, it transmits that data to all of the neurons in the layer below it, forming a feedforward path to the ultimate output [5]. Neural networks were created to replace the inaccuracy of classic categorization methods

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such as perceptrons. It is evident that stacking perceptrons may increase accuracy. This resulted in the creation of a brand-new technology for machine learning known as multi-layer perceptrons. Training is the process through which a neural network changes its parameters after each iteration to enhance the performance of the classifier [6].

A. Types

1) Feed-Forward

Frequently, feed-forward neural networks are used to comprehend the relationship between inputs (independent variables) and outputs (dependent variables). It is categorized into two types, single-layer and multilayer. Backpropagation is used to train a multilayer FFNN by feeding it a series of input samples and comparing its anticipated output to the actual responses over time. Training will continue until the network provides the needed and convincing responses. The network architecture is the pattern of connections between and within the various neuronal layers. Depending on the number of weighted links between the different neuron "slabs," a network may have one or many layers [7]. With the disadvantages of port-based and payload-based classification methods eliminated, a new technique for accurate traffic categorization based on feed-forward neural networks is proposed in the cited paper [8].

2) Normal Radial Basis Function (NRBF)

The General Regression Neural Network (GRNN) and RBF are two neural network types with many similarities, and the NRBF combines the best characteristics of both. The sole difference between the NRBF and a standard Radial Basis Function (RBF) network is that the NRBF normalizes the outputs of the hidden layer before sending them to the output layer. RBF utilizes hidden layer basis functions that are locally responsive to input. Typically, Gaussian kernel functions are utilized to create these covert nodes [9].

3) Radial Basis Function (RBF)

With its single hidden layer, this network represents a new paradigm in the domain of neural network structures. RBFNs are characterized by their capability to describe sophisticated non-linear mapping and their incorporation of a rapid, linear learning mechanism. Depending on the complexity of the input and output predictor variables, each hidden layer neuron is represented by a centered RBF. The concept originates in the study of approximating functions. To better represent the distribution of the datapoints, a set of centers may be determined using clustering algorithms [10]. When training a neural network, if one or more classes has much less examples than the others, the system may erroneously react for the minority classes since the adjustment technique is influenced by the majority classes' inputs. Such class-dependent predictor variables will have to be chosen from real-world examples, for instance, in medical image classification. Due to its usefulness in a variety of settings, including interpolation, data mining, and optimum classification, exploration into a training approach of RBF neural networks handling imbalanced input is encouraged. RBF neural networks are widely used because they can be trained quickly and can provide global approximation with local responses. Making an RBF neural network that is both small in size and resistant to imbalanced input is a daunting problem, but this is true of all neural networks [11].

4) Convolutional Neural Networks

It is an advanced version of a multilayer perceptron. By restricting the number of nodes in a feedforward network and depending on weight sharing, convolutional neural networks may minimize the network's complexity. This network architecture has been used in the area of image classification notably when extensive pre-processing is not necessary and raw images must be studied instantly. Convolutional Neural Networks have attempted to increase efficiency and accuracy in all industries where they have been used. Popular Convolutional Neural Network applications include Object Detection and Digit and Image Recognition [12]. In [13], an extension of the neocognitron is introduced, which incorporates neurons from the perceptron into the neocognitron's closed-loop network architecture. To identify more complex characteristics, this study uses a modular procedure in which layers are trained gradually from the input to the output layer, as opposed to the time-consuming error backpropagation used in previous studies.

B. Applications

1) Gaming

For many difficult problems, including those pertaining to national security, management science, environmental considerations, etc., the gaming technique has shown to be efficient. In a more nuanced game, players face a genuine scenario in which they must discuss and decide on a course of action as a group. Therefore, gaming seems like a viable instrument for dealing with complicated problems in which human actions have far-reaching consequences for others [14]. The reason why people have attempted to include ANNs into video games for so long is straightforward. ANNs are all about learning, and many game designers and programmers have desired for quite some time to make more use of learning technologies. Digital games may facilitate both online and offline learning processes. We just need to train the AI once, during the development process, since offline learning is used. The AI will cease to learn while the game is played after the game has been initiated. Neural networks may be used to more than only the strategic components of commercial digital games of the present day [15].

2) Fraud Prevention

Data analysis techniques that have been around for a while have long been used to recognize fraud. They call for extensive research covering several topics, including corporate law, economics, and finance. Multiple incidences of the same kind of fraud, committed in the same way, are not infrequent. Since fraud is a dynamic offense, unique approaches to intelligent data analysis are required for detection and prevention. Technology based on neural networks has given computers the ability to reason. There is a consistent pattern of credit card usage that arises from the way a certain customer makes purchases with their card. A neural network is trained on an individual's credit card spending habits based on data from the last year or two. However, credit card fraud experiences by a certain bank are also included into the neural network's training. Neural networks employ a prediction algorithm on credit card transaction patterns to determine the legitimacy of an individual purchase [16].

3) Social Media

Social media consists of enormous data sets that are perfect for applying neural networking to as it uses deep learning. In addition, corporations and institutions have paid growing attention to the potential of Deep Neural Network applications in the field of social media [17]. In [18], user sentiment is classified using convolutional and recurrent neural networks, as well as other machine learning techniques (CNN and RNN). Fig. 1 depicts how neural networks may be used within the context of social media.

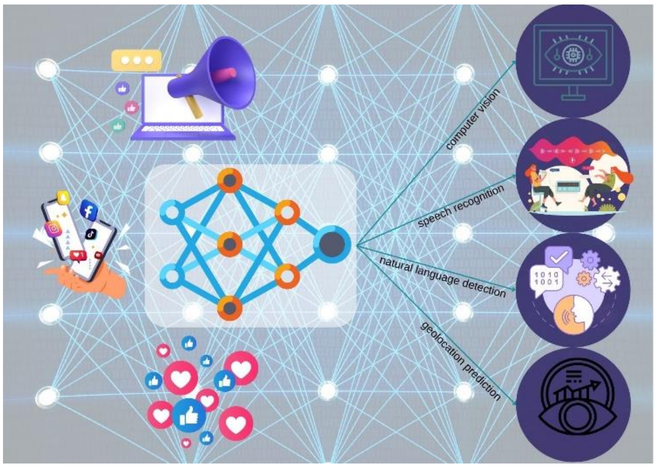

Fig. 1. Implications of neural networks in social media

4) Marketing and Sales

Nowadays, corporations may access massive troves of information about their clients. These facts may be leveraged to get to know each client on an individual basis, enabling the firm to adapt its products to each one. Numerous consumer and market databases are preserved for this similar purpose. Direct marketing has become an important use of data mining, in part because of its growing relevance. In selecting targets for commercial applications, neural computing is merely one of the various methods that have been utilized [19].

For strategic planning objectives, it's crucial to precisely forecast future revenues. Numerous research has been conducted on this topic, with the majority using statistical methods such as regression, autoregression, and moving average. Artificial neural networks (ANNs) outstanding track records in control and pattern recognition have led to their use in sales forecasting [20]. Recently, Bigus [21] applied the ANN to predict weekly demand based on inputs like promotion, time of year, and end-of-month flag. The results are really favourable overall. Agrawal and Schorling [22] show that when price promotions, features, and displays are included in the data set, ANN can still properly predict brand shares.

For economic and marketing research, exploratory multivariate modelling with ANNs provides various advantages over more conventional techniques such as multiple linear regression. ANNs are able to identify correlations between the dataset's dependent and independent variables. Moreover, they may tweak the current model or create a new regression model to account for any emerging patterns. Artificial neural networks (ANNs) can easily manage data with gaps, outliers, and nonlinear changes. In addition, NNs are adaptable and learn from their experiences, enabling them to precisely imitate and choose models for recurring patterns. Additionally, ANNs may be used to compare and coordinate the performance of several models. In particular, NNs excel in pattern recognition and huge optimization [23]. The possible uses of ANNs in the business world, namely in the realms of marketing and sales are depicted in Fig.2.

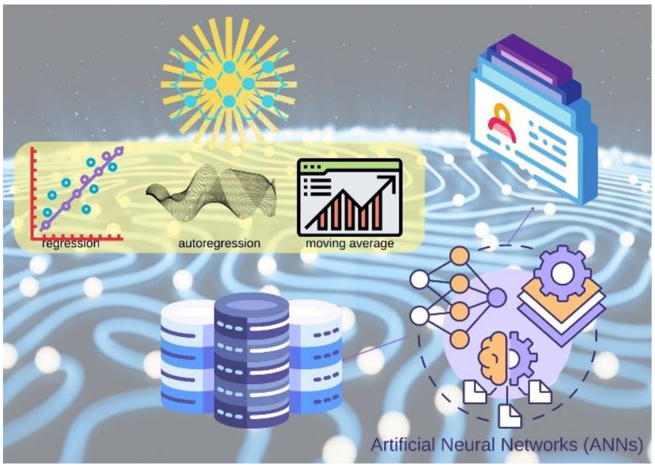

Fig. 2. The function of ANNs in sales and marketing

III. MACHINE LEARNING

To assist computers in processing information more efficiently, researchers have turned to machine learning (ML). After examining the data, they are not always able to determine how to use it. When this happens, machine learning is used. As more and more datasets become available, machine learning is growing in popularity. Several mathematicians and computer scientists use various approaches to address this problem, which includes very big data sets. Various machine-learning-based techniques may be used to address data-related difficulties. Data scientists are fond of stating that there is no silver bullet for finding the most effective solution to a particular problem. Numerous aspects, such as the nature of the problem, the number of variables involved, the kind of successful design, etc., dictate the approach used [24].

For instance, the current success of ML in the field of image recognition may be attributed to significant improvements over earlier methods. These achievements were early signs of the impact that machine learning techniques may have on specialised endeavours. Deep learning technology, in particular, has enabled hitherto unattainable uses for automated software. For example, the use of reinforcement learning techniques in gameplay had a significant impact on the prevalent notion that the area was moving closer to what was predicted for general artificial intelligence (AI) [25].

Machine learning is crucial because it allows computers to do challenging tasks with little or no human intervention based on learning and steadily growing experience with the aim of recognising the complexity of situations and the necessity for continuous adaptation. Humans do a broad array of tasks on a regular basis, but what matters most is that they are performed precisely and according to a set plan. Examples include voice recognition and cooking. In sectors such as weather forecasting, remote sensing, e-commerce, web search, etc., where human skills fall short, machine learning shines in the processing of large and difficult data sets. When presented with huge amounts of data, it becomes incredibly difficult for people to make precise predictions. Historically, machine learning has been shown to be successful in independently resolving data science difficulties. In order to better interpret and analyse real-world occurrences, data science is defined as "a paradigm that combines data analysis, statistics, and machine learning together with their accompanying methodologies." Prior to trying to solve a problem, it must be correctly classified so that the most appropriate ML technique may be employed [26].

A. Types

1) Supervised Machine learning

Categories are predefined for supervised algorithms. Because these categories are created using human-defined criteria, they can only be allocated a portion of the available data. The purpose of machine learning algorithms is to analyse data in order to create prediction models. To get a final score, the predictive performance of these models is compared to measures of variance in the actual data [27].

2) Unsupervised Machine Learning

The objective of unsupervised machine learning methods is to discover relationships in such a data structure despite the presence of a measurable outcome, making them particularly useful for job descriptions. This is known as "unsupervised learning," as there is no response variable to function as a supervisor. Unsupervised learning aims to uncover hidden dimensions, groups, components, and trajectories within a dataset. Principal component analysis, mixture modelling, and factor analysis are examples of unsupervised learning techniques widely used in the classification and psychometric research of mental health [28].

3) Semi-supervised Machine Learning

Methods for machine learning (ML) include semi-supervised learning (SSL). This kind of learning falls between completely supervised and entirely unsupervised, with the dataset being somewhat annotated in both instances. SSL tries to overcome the problems inherent in both unsupervised and supervised learning since both have deficiencies. Using supervised learning to classify test data is a costly and time-consuming process that requires a huge amount of training data. Unsupervised learning does not need labelled data to perform, while supervised learning must. Instead, it organises data according to their similarities, either by grouping or using the expectation-maximization approach. This approach is fundamentally flawed since it cannot accurately cluster unknown data. SSL has been advocated by researchers as a solution since it can label test data with a small amount of training data. SSL builds a model using just a portion of the annotated patterns as training data, while the other patterns serve as test data [29].

4) Reinforcement Learning

Reinforcement learning (RL) explores how artificial and natural systems may learn to optimise their behaviour by anticipating the outcomes of scenarios in which their actions lead them to various states or circumstances and may be rewarded with both rewards and penalties. Several academic areas, including economics, ethology, control theory, and psychology, examine similar conditions. Surprisingly, all types of animals, from the timidest to the most audacious, have to cope with these sorts of optimization issues, and they all seem to find rather effective answers. RL, which evolved from operations research and mathematical psychology, provides both qualitative and quantitative models of these computer science-level challenges [30].

B. Applications

1) Medical Diagnosis

Machine learning (ML) technologies are being in healthcare for decision-making with the goals of eliminating diagnostic errors and ensuring that patients receive the most appropriate medicines. The exponential expansion of accessible medical data and the development of methods for storing and analysing that data have also led to the broad use of machine learning in medicine. Machine learning (ML) is a method for making computers smarter by allowing them to use their own past experiences to improve their performance. Utilizing historical data and mathematical modelling approaches, the model optimises the parameters that it infers from the massive dataset. In contrast to more conventional techniques, which depend on explicit programming of the whole model via rules, this method uses historical data [31].

Assuming the broad use of electronic health records by healthcare providers, the algorithms designed for these markets offer significant potential for increasing medical research and patient care. In the fields of diagnostics and outcome estimation, the healthcare sector may gain a great deal from the use of machine learning techniques. When it comes to finding diagnostic and prognostic components, ML is not only able to handle varied real-world data configurations and apply context weighting, but it can also evaluate the prediction capability of any imaginable combination of elements. ML models trained on clinical data may help identify urinary tract infections, aphasia speech types, and even breast cancer, acting as a "second opinion" for doctors. The ability to swiftly analyse huge data sets, much beyond the limits of human competence, into clinical information that helps doctors plan and deliver treatment, resulting in improved results, lower medical costs and increased patient satisfaction, Precision medicine, therapeutic recommendations, and disease diagnostics are all areas in which ML may play a role and currently do so. In the field of H-IoT, ML is also being used to analyse and manage huge quantities of healthcare data generated by sensors. Accordingly, several studies have been conducted to establish its effectiveness in treating a variety of illnesses [32]. The results of machine learning in medicine are shown in Fig. 3.

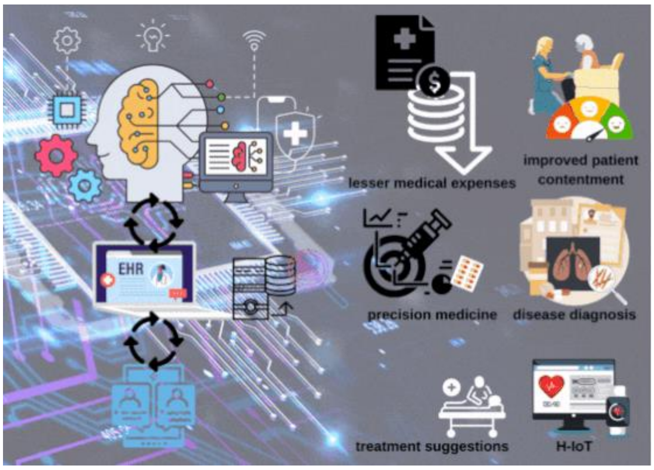

Fig. 3. Medical outcomes achieved by machine learning

2) Product Recommendation

The term "product recommendation" (PR) refers to a model or system that makes product recommendations based on a user's browsing and purchasing history. It may not be 100 per cent correct, but it may be close enough for the user to appreciate. The kind of suggestion delivered to the user is dependent on the available data. Filtration methods may include: Using collaborative filtering, product suggestions are generated. Filters may be created by the user or based on certain components. The recommendation of products is based on the purchase patterns of similar users. Object filtering is a mechanism for recommending a product to a consumer based on the resemblance between that product and a previously purchased one. A recommendation system can provide essential information (RS). If the user has no real interest in the goods being offered, the RS may be considered spam. Each individual's recommendation system is tailored to their profile. Utilizing a previously published recommendation model may increase the value of the dataset; consequently, this model may be improved [33].

Today, recommendation systems play a crucial role in a range of industries, including commerce, education, businesses, healthcare, the government, and others. The suggestion system was first used in online purchasing. Over time, the concept of recommendation systems grew to permeate new situations [34]. As shown in Fig. 4, ML is being used for the task of product recommendation.

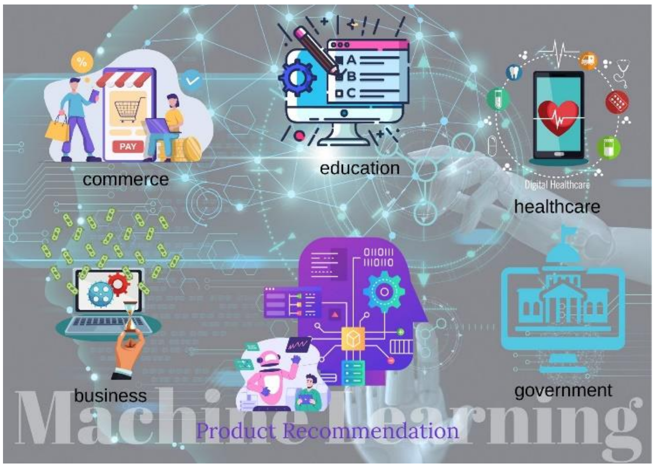

Fig. 4. Utilizing ML in the area of product recommendation

3) Traffic Prediction

Intelligent transportation systems (ITS) cannot work without traffic projections. By analysing historical data, traffic prediction attempts to forecast how people will use a transportation network in the future. There are two separate subfields of traffic forecasting: short-term forecasting and long-term forecasting, which respectively concentrate on the projected course of events in the near future and farther into the future [35].

The vast majority of traffic flow prediction techniques use artificial neural networks (ANNs). Automatic neural networks (ANNs) are a class of statistical learning strategies. They are capable of handling challenging scenarios, such as those with missing or noisy data. ANNs have layers, with the multilayer perceptron (MLP) being the most prevalent variety(ANNs). Automatic neural networks (ANNs) are a class of statistical learning strategies. They are capable of handling challenging scenarios, such as those with missing or noisy data. ANNs have layers, with the multilayer perceptron (MLP) being the most prevalent variety. The ultimate aim of an ANN is to provide a forecast with a minimal MSE (mean squared error). Neurons are the fundamental computational building blocks of ANNs; they receive a variety of data points, or inputs, and then create a single output using a form of internal weighting. There are different neuronal layers. The usage of ANNs is costly owing to the number of training sets that must be saved, which can only be managed by a parallel architecture that can process enormous amounts of data in a short amount of time [36].

IV. Conclusion

In conclusion, the past two decades have seen significant progress in the field of neural networks and machine learning, both of which complement each other. Recent development in the field of NN management has been summarized. The widespread use of neural networks in fields like content-addressable memory, pattern recognition, and optimization has led to a surge in the field's popularity in recent years. It may be thought of as the minimization of an error function that represents the deviation between the network's actual output and the desired output for a given set of training data. It is utilized in many fields that require the analysis of large data sets. Also, the second section of the paper details the process of machine learning, that is making the machine adapt to instructions through learning methods such as deep learning. Application of the field in medicine, product recommendation and traffic prediction have also been discussed.

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