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Development and Application of Artificial Neural Network

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Abstract Artificial neural network is a very important part in the new industry of artificial intelligence. In China, there are many researches on artificial neural network and artificial intelligence are developing rapidly. Therefore, this paper reviews and summarizes artificial neural network, and hopes that readers can get a deeper understanding of artificial neural network. This paper first reviews the development history of artificial neural network and its related theory, and introduces four major characteristics of artificial neural network, such as the non-linear, non-limitative, non-qualitative and non-convex. Then it emphatically analyzes its application in information, medicine, economy, control, transportation and psychology. Finally, the future development trend of artificial neural network is prospected and summarized.

Keywords Artificial neural network · Development history · Application status analysis · Future development trend

1 Introduction

Artificial Neural Network (ANN) is a hot topic in artificial intelligence since the 1980s. It abstracts the human brain neural network from the perspective of information processing, establishes a simple model and compose different networks according to different connections [1]. Trying to simulate the brain neural network processing, memory information in the way of information processing. In engineering and academia are often directly referred to as neural network or neural network. Neural network is a computing model, by a large number of nodes (or neurons) connected to each other [2]. Each node represents a specific output function, called the activation function. The connection between every two

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nodes represents a weight for the signal passing through the connection, which is called the weight, which is equivalent to the memory of the artificial neural network [3]. The output of the network will vary depending on how the network is connected, the weight value, and the incentive function. However, the network itself is usually an approximation to some kind of algorithm or function in nature, or it may be an expression of a logic strategy [4].

In an artificial neural network, a neuron processing unit can represent different objects, such as features, letters, concepts, or some meaningful abstraction pattern. The type of processing unit in the network is divided into three categories: input unit, output unit and hidden unit. The input unit accepts signals and data from the outside world [5]. The output unit realizes the output of the system processing result. The hidden unit is a unit that is located between the input and output units and cannot be observed outside the system [6]. Connection weights between neurons reflect the connection strength between cells. The representation and processing of information are embodied in the connection relationship of the network processing unit. Artificial neural network is a non-program, adaptive, brain-style information processing, its essence is through the network transformation and dynamic behavior of a parallel distributed information processing functions, and in varying degrees and levels of imitation of people Information processing of the brain and nervous system [7]. It is involved in various fields of neuroscience, thinking science, artificial intelligence, computer science and other interdisciplinary.

Artificial neural network is a parallel distributed system, which adopts a totally different mechanism from traditional artificial intelligence and information processing technologies, overcomes the defects of the traditional logic-based artificial intelligence in handling intuition and unstructured information, and has the advantages of adaptive, self-organizing and real-time learning features [8].

In recent 10 years, great progress has been made in the research work on artificial neural networks. Many achievements have been made in such fields as pattern recognition, intelligent robot, automatic control, prediction and estimation, biology, medicine, economy and so on. It has solved the practical problems that modern computers cannot solve have and shown good intelligence [9] (Fig. 1).

2 Artificial Neural Network Development Process

Artificial neural network development process can be broadly divided into four stages, namely, the rise stage, the ebb stage, the revival stage, the flourishing stage.

2.1 The First Phase: Rise

In the 1940s, people began to study neural networks. In 1943, American psychologist Mcculloch and mathematician Pitts proposed the M-P model, which is a simple but significant one. In the model, the algorithm is realized by considering the neuron as a functional logic device, thus starting the theoretical research of the neural network model. In 1949, psychologist Hebb published "The Organization of Behavior", in which he proposed the hypothesis that the intensity of synaptic connections is variable. This hypothesis suggests that the learning process ultimately occurs at the synaptic interface between neurons, and the intensity of the synaptic connections varies with the activity of the neurons before and after the synapse. This hypothesis evolved into a well-known Hebb rule in neural networks. This law tells people that the strength of synaptic connections

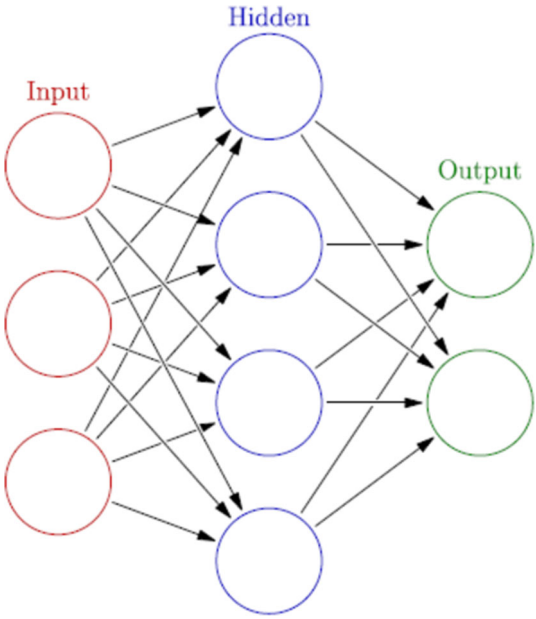

Fig. 1 Artificial neural network

among neurons is variable, and that variability is the basis for learning and memory. The Hebb law lays the foundation for constructing a neural network model with learning function. In 1957, Rosenblatt proposed the Perceptron model based on the M-P model. Perceptron model has the basic principle of modern neural network, and its structure is very much in line with neurophysiology. This is an MP neural network model with continuously adjustable weights. After training, it can achieve the purpose of classifying and recognizing a certain input vector mode. Although it is relatively simple, it is the first true neural network. Rosenblatt proved that two-layer sensors can classify inputs, and he also proposed an important research direction for three-layer sensors with hidden layer processing elements. Rosenblatt's neural network model contains some of the basic principles of modern neural computer, which form a major breakthrough in neural network methods and technologies. In 1959, well-known American engineers B. Widrow and M. Hoff et al. proposed a neural network training method of adaptive linear element (Adaline) and Widrow–Hoff learning rules (also known as least mean square deviation algorithm or δ rule), and apply it to the actual project, becoming the first artificial neural network to solve practical problems, and promote the application and development of neural network research. The ADALINE network model is a continuous-valued adaptive linear neuron network model that can be used for adaptive systems.

2.2 The Second Phase: Ebb

Minsky and Papert, one of the founders of artificial intelligence, conducted a mathematic study on the functions and limitations of the network system represented by perceptron. In 1969, he published a sensational book called 'Perceptrons', pointing out that the function of simple linear perception is limited. It cannot solve the classification problem of two types of linear inseparable samples. For example, the simple linear sensor cannot realize the logical relationship of XOR. This conclusion has brought a heavy blow to the research

of artificial neural network at that time. Beginning in the history of neural network up to 10 years of low tide.

In 1972, Professor Kohonen T. of Finland proposed Self-Organizing Feature Map (SOM). Later neural networks were mainly based on the work of Kohonen T. SOM network is a kind of tutor learning network, mainly used for pattern recognition, speech recognition and classification problems. It adopts a competitive learning algorithm of "winner is king", which is very different from the perceptron proposed earlier. At the same time, its learning and training method is a self-organizing network without instruction training. This kind of learning and training method is often used as a kind of training to extract classified information without knowing what type of classification exists. In 1976, Professor Grossberg proposed the famous Adaptive Resonance Theory (ART), which has the characteristics of self-organization and self-stability.

2.3 The Third Phase: Revival

In 1982, American physicist Hopfield proposed a discrete neural network, that is, a discrete Hopfield network, which effectively promoted the research of neural networks. In the network, it introduces Lyapunov function for the first time. Later researchers also called Lyapunov function as energy function. Prove the stability of the network. In 1984, Hopfield proposed a continuous neural network to change the activation function of neurons in the network from discrete to continuous. In 1985, Hopfield and Tank used the Hopfield neural network to solve the famous Traveling Salesman Problem. Hopfield neural network is a set of nonlinear differential equations. Hopfield's model not only performs nonlinear mathematical summarization on the information storage and retrieval function of artificial neural network, but also provides dynamic equations and learning equations. It also provides important formulas and parameters for the network algorithm, which makes the construction and learning of artificial neural network have the theory under the influence of Hopfield model, a large number of scholars stimulate the enthusiasm of studying neural networks and actively participate in this academic field. Because of the great potential of Hopfield neural network in many aspects, people pay more attention to the research of neural network. More and more people begin to study the neural network and greatly promote the development of neural network. In 1983, Kirkpatrick et al. realized that the simulated annealing algorithm can be used to solve the NP complete combinatorial optimization problem. The method of simulating the annealing process of high temperature objects to find the global optimal solution was first proposed by Metropli et al. in 1953. In 1984, Hinton, in collaboration with young scholar Sejnowski et al., proposed a large-scale parallel online learning machine and explicitly proposed the concept of a hidden unit, which was later called the Boltzmann machine. Hinton and Sejnowsky use the concept of statistical physics and methods, the first proposed multi-layer network learning algorithm, known as the Boltzmann machine model. In 1986, based on the multi-layer neural network model, D.E. Rumelhart et al. proposed the back propagation algorithm BP algorithm (Error Back Propagation) to solve the problem of multi-layer neural network weight correction The learning problem of the forward neural network proves that the multi-layer neural network has strong learning ability, it can accomplish many learning tasks and solve many practical problems. In 1988, Chua and Yang proposed a cellular neural network (CNN) model, which is a large-scale nonlinear computer simulation system for cellular automata. Kosko has established a bi-directional associative storage model (BAM) that has unsupervised learning capabilities. In 1991, Haken introduced synergy to neural networks. In his theoretical framework, Haken believes that the cognitive process is spontaneous and

asserts that the pattern recognition process is the process of pattern formation. In 1994, Liao Xiaoxin put forward the mathematical theory and foundation of cellular neural network, bringing new progress in this field. By broadening the activation function classes of neural networks, more general delayed cellular neural networks (DCNN), Hopfield neural networks (HNNs) and bidirectional associative memory networks (BAMs) are given. After years of development, hundreds of neural network models have been proposed.

2.4 The Fourth Stage: Flourishing

Deep Learning (DL), proposed by Hinton et al. in 2006, is a new field of Machine Learning (ML). In essence, deep learning is to construct a machine learning architecture model with multiple hidden layers, and a large amount of more representative characteristic information is obtained through large-scale data training. Depth learning algorithm to break the traditional neural network limit the number of layers, according to the designer needs to select the network layer.

2.5 Artificial Neural Network has Four Basic Characteristics

1. Non-linear. Non-linear relationship is a universal feature of nature. The brain's intelligence is a non-linear phenomenon. Artificial neurons in the activation or inhibition of two different states, this behavior in the mathematical performance of a non-linear relationship. A network of neurons with thresholds has better performance and can improve fault tolerance and storage capacity.
2. Non-limited. A neural network usually consists of multiple neurons connected together. The overall behavior of a system depends not only on the characteristics of a single neuron but also on the interaction and interconnection of the units. The non-limiting brain is modeled by the large number of connections between cells. Associative memory is a non-limiting example.
3. Non-qualitative. Artificial neural network with self-adaptive, self-organizing, self-learning ability. Neural networks not only process the information can have a variety of changes, but also in dealing with the information, nonlinear dynamical system itself is constantly changing. The iterative process is often used to describe the evolution of a dynamical system.
4. Non-convexity. The evolutionary direction of a system, under certain conditions, will depend on a particular state function. For example, the energy function, its extreme corresponding to the system more stable state. Non-convexity means that this function has multiple extrema, so the system has more stable equilibrium states, which will lead to the diversity of system evolution.

2.6 The Characteristics and Superiority of Artificial Neural Network are Mainly Manifested in Three Aspects

First, with self-learning capabilities. For example, when image recognition is implemented, many different image templates and corresponding identifiable results are input to an artificial neural network, and the network gradually learns to recognize similar images through the self-learning function [10]. Self-learning is particularly important for forecasting. Prospective future artificial neural network computer will provide mankind with

economic forecast, market forecast and benefit forecast, and its application prospect is far-reaching.

Second, with Lenovo storage capabilities. The artificial neural network feedback network can achieve this association.

Third, the ability to find optimal solutions at high speeds. Finding the optimal solution to a complex problem often requires a large amount of computation. Using a feedback-type artificial neural network designed for a problem, the computer's high-speed computing power can be exploited to find the optimal solution quickly [11] (Fig. 2).

3 Artificial Neural Network Application Status Analysis

After decades of development, neural network theory has achieved a great success in many fields of research, such as pattern recognition, automatic control, signal processing, decision support, and artificial intelligence. The following describes the application of neural networks in some areas of the status quo.

3.1 Artificial Neural Network in the Field of Information Applications

In dealing with many problems, the sources of information are neither complete nor illusive. Decision rules are sometimes contradictory and sometimes absent. This poses great difficulties for the traditional information processing methods, but the neural network can be very good deal with these problems, and give a reasonable identification and judgments.

(1) Information processing

The problems to be solved by modern information processing are very complicated. Artificial neural network has the function of imitating or replacing people's thinking, and it can realize automatic diagnosis, solving problems and solving problems that cannot be

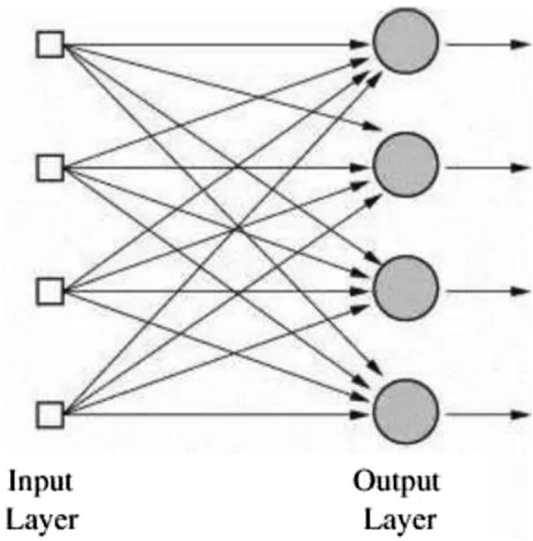

Fig. 2 Input and output of artificial neural network

solved by traditional methods. Artificial neural network system with high fault tolerance, robustness and self-organization, even if the connection was a high degree of damage, it can still be in optimal working condition, which is widely used in military system electronic equipment application. The existing intelligent information systems include intelligent instruments, automatic tracking and monitoring instrumentation systems, automatic control guidance systems, automatic fault diagnosis and alarm systems.

(2) Pattern Recognition

Pattern recognition is the process of describing, identifying, classifying, and interpreting things or phenomena by processing and analyzing various forms of information that characterize things or phenomena. The technology based on the Bayesian probability theory and Shennong's theory of information as the theoretical basis, the process of information processing closer to the human brain logical thinking process. There are now two basic pattern recognition methods, statistical pattern recognition and structural pattern recognition. Artificial neural network is a common method in pattern recognition. In recent years, the artificial neural network pattern recognition method gradually replaces the traditional pattern recognition method. After years of research and development, pattern recognition has become the current more advanced technology and has been widely applied to character recognition, speech recognition, fingerprint recognition, remote sensing image recognition, face recognition, recognition of handwritten characters, industrial fault detection, precise guidance, etc. aspect.

3.2 Artificial Neural Network in the Field of Medicine

Due to the complexity and unpredictability of the human body and the disease, the detection and signal expression of the biological signal and the manifestation of the information, the variation of the biological signal and the manifestation of the information (changes after self-change and medical intervention), the data and information obtained, Decision-making and many other aspects there is a very complex nonlinear relationship, suitable for the application of artificial neural network. The current research involves almost all aspects from basic medicine to clinical medicine, mainly used in the detection and automatic analysis of biological signals, medical expert system and so on.

(1) Biological signal detection and analysis

Most medical testing equipment outputs data in a continuous waveform, which is the basis for diagnosis. Artificial neural network is a kind of adaptive dynamical system which is connected by a large number of simple processing units. It has the functions of huge amount of parallelism, distributed storage and self-adaptive learning, which can be used to solve the problem of biomedical signal analysis and processing Problems that cannot be solved by conventional law. The application of neural network in biomedical signal detection and processing mainly focuses on the analysis of EEG signal, the extraction of auditory evoked potential signal, the identification of EMG and gastrointestinal signals, the compression of ECG signals, the recognition of medical images And so on.

(2) Medical expert system

The traditional expert system is to store the experience and knowledge of experts in the form of rules in the computer, to establish a knowledge base, and to use the way of logical reasoning for medical diagnosis. However, in practical applications, as the size of the database increases, it will lead to "explosion" of knowledge and "bottleneck" in the access

to knowledge, resulting in low efficiency. The neural network based on nonlinear parallel processing points out a new development direction for the research of expert system, solves the above problems of expert system, and improves the knowledge inference, self-organization and self-learning ability, so that neural network is widely used by medical experts The system has been widely used and developed. In the field of anesthesia and critical medicine and other related research, involves the analysis and prediction of multiple physiological variables in the clinical data there are still some not found or no accurate evidence of the relationship between the phenomenon, the signal processing, automatic detection of interference signals, The prediction of various clinical conditions, etc., can be applied to artificial neural network technology.

3.3 Artificial Neural Network in the Field of Economic

(1) Market price forecast

An analysis of changes in commodity prices can be attributed to a comprehensive analysis of the many factors that affect the supply–demand relationship in the market. Because of its inherent limitations, the traditional statistical economics method is difficult to predict the price changes scientifically. However, the artificial neural network is easy to deal with incomplete, fuzzy uncertain or regular data, so artificial neural network Price forecasting is an advantage that cannot be compared with traditional methods. Starting from the mechanism of determining the market price, a more accurate and reliable model is established based on the complex and ever-changing factors such as the number of households affected by commodity prices, per capita disposable income, loan interest rate and urbanization level. The model can predict the changing trend of commodity prices and obtain accurate and objective evaluation results.

(2) Risk assessment

Risk refers to the possibility of natural or financial damage or damage caused by the uncertainties in the process of engaging in a particular activity. The best way to prevent a risk is to make a scientific prediction and assessment of the risk in advance. The prediction of applying artificial neural network is to construct the structure and algorithm of credit risk model suitable for the actual situation according to the actual source of risk, get the risk evaluation coefficient, and then determine the solution of the actual problem. Empirical analysis using this model can make up for the lack of subjective assessment, can achieve satisfactory results.

3.4 Artificial Neural Network in the Field of Control Applications

Artificial neural network has been widely used in control system because of its unique model structure and inherent nonlinear simulation ability, as well as the outstanding features of highly adaptive and fault-tolerant. Based on the frame structure of various controllers, a nonlinear adaptive learning mechanism is added to make the controller have better performance. The basic control structure has supervision and control, direct inverse mode control, model reference control, internal model control, predictive control, optimal decision control and so on.

3.5 Artificial Neural Network in the Field of Transport Applications

In recent years, people began to conduct in-depth research on the application of neural network in transportation system. Transportation problems are highly non-linear and the data available are often large and complex. It has great advantages in dealing with related problems using neural networks. Applications include vehicle driver behavior simulation, parameter estimation, pavement maintenance, vehicle detection and classification, traffic pattern analysis, cargo operation management, traffic flow forecasting, transportation strategy and economy, traffic environmental protection, air transportation, automatic navigation of ships and Identification of vessels, subway operations and traffic control and other fields and has achieved good results.

3.6 Artificial Neural Network in the Field of Psychology

Since the formation of neural network model, it has a close relationship with psychology. Neural network abstracts the information processing function of neurons, neural network training reflects the cognitive, memory, learning and other cognitive processes. People constantly study and change the structure model and learning rules of artificial neural network to explore the cognitive function of neural network from different perspectives and lay a solid foundation for their research in psychology. In recent years, the artificial neural network model has become an indispensable tool for exploring advanced psychological process mechanisms such as social cognition, memory and learning. Artificial neural network model can also study cognitive deficits in patients with brain injury, which poses challenges to the traditional cognitive localization mechanism.

Although some improvements have been made in the artificial neural network, there are still some shortcomings. For example, the applied surface is not wide enough and the result is not accurate enough. The existing model algorithms do not train well enough and the algorithm integration is not high enough. At the same time, Seek new breakthrough points in theory and establish new common models and algorithms. It is necessary to further study the biological neuron system and continuously enrich people's understanding of human brain.

4 Artificial Neural Network Future Development Trend

The unique nonlinear adaptive information processing ability of artificial neural network overcomes the shortcomings of traditional artificial intelligence methods such as intuition, mode, speech recognition and unstructured information processing, making them more effective in neurological expert systems, pattern recognition, intelligent control, Portfolio optimization, forecasting and other fields have been successfully applied [12]. The combination of artificial neural networks and other traditional methods will drive the continuous development of artificial intelligence and information processing technologies. In recent years, artificial neural network has been further developing on the road of simulating human cognition. Combining with fuzzy system, genetic algorithm, evolutionary mechanism and so on, forming artificial intelligence becomes an important direction of artificial intelligence and will be developed in practical application [13]. The application of information geometry to artificial neural network has opened up a new way for the theoretical research of artificial neural network. Nerve computer research and development is

fast, have products to market. Optically and electronically coupled neural computers provide good conditions for the development of artificial neural networks [14].

Neural networks have been well used in many fields, but there are still many aspects that need to be studied. Among them, the combination of neural networks with other technologies, such as distributed memory, parallel processing, self-learning, self-organizing and nonlinear mapping, as well as the hybrid methods and hybrid systems, have become a hot research topic. As other methods also have their own advantages, so the neural network combined with other methods, learn from each other, and then you can get better results [15]. At present, the work in this area includes the fusion of neural network and fuzzy logic, expert system, genetic algorithm, wavelet analysis, chaos, rough set theory, fractal theory, evidence theory and gray system.

5 Conclusion

This paper reviews the development of artificial neural network in a phased manner and introduces the characteristics of artificial neural network and its application in fields of information, medicine, economy, control, transportation and psychology. Artificial neural network is an important branch of artificial intelligence, with adaptive, self-organizing and self-learning features. As people continue to explore and research the artificial neural network and combine it with some traditional methods, such as the PPP model, it will promote the development of artificial intelligence and play a greater role in the later production and life.

Future research directions can be divided into two major aspects: theoretical research and applied research:

Theoretical research can be divided into the following two categories:

1. The use of neurophysiological and cognitive science to study human thinking and intelligent mechanisms.
2. Using the research results of neural basic theory, we explore the neural network model with more perfect function and superior performance by using mathematical methods, and deeply study the network algorithm and performance, such as: stability, convergence, fault tolerance, robustness and so on; The new network theory, such as: neural network dynamics, nonlinear neurons and so on.

Applied research can be divided into the following two categories:

1. The neural network software simulation and hardware research.
2. The application of neural networks in various fields. These areas include: pattern recognition, signal processing, knowledge engineering, expert systems, optimization, robotic control and more. With the continuous development of neural network theory and related theories and related technologies, the application of neural networks will certainly be more in-depth.

At the same time, the artificial neural network can be used to optimize the data and model in the PPP model, which will also be one of the author's future research directions.

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