Optimization of Composite Properties by Artificial Intelligence

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ABSTRACT: This paper will summarize and study the application of artificial intelligence to composites in the past and present, and predict the development of materials by using artificial intelligence in the future. This paper will use the method of summarizing and summarizing the law from other literature. The summary of artificial intelligence in composites predicts the future development of artificial intelligence, and summarizes and clarifies the development path of artificial intelligence in composites in the future. In the context of the rapid development of artificial intelligence, using artificial intelligence to synthesize or optimize composites has become the trend of material synthesis. This will bring a new way of material synthesis.

1. INTRODUCTION

1.1 Background of composites materials

The use of composite materials dates back to the period of primitive human civilization tens of thousands of years ago. At that time, the earliest composite materials were clay bricks made by mixing straw with clay mud. Lacquerware is the most eye-catching composite material. It was made in China 4000 years ago. It is made of silk, hemp, and other reinforcing agents and then pasted with fire paint.

Since modern times, due to the rapid development of aviation and the aerospace industry, the requirements for strength, modulus, and high-temperature resistance of materials have gradually increased, so advanced composites came into being. Moreover, these advanced composite materials have greatly promoted the development of the human aerospace industry, which is extremely important in contemporary science and technology development.

1.2 Properties of composites materials

Composite material is a new material synthesized from several different materials. It can retain the main characteristics of the raw materials and obtain the properties that the raw components do not have through the composite effect.

As a composite of two or more materials, the composite material has very high operability. The traditional single material has very single properties and has limitations in use [1]. However, composites can be flexibly synthesized from other materials, which can meet various mechanical properties, structural characteristics, and so on. It greatly increases the upper limit of various building materials. The new composite materials can produce new materials with lighter weight but higher strength and modulus through the above characteristics, and can also achieve the advantages of good fatigue resistance, good shock absorption performance, high-temperature resistance, good safety, and so on [2]. These characteristics are the materials required in aerospace. Therefore, this paper will discuss these problems one by one and will solve and predict these problems and future development.

1.3 Problems and difficulties of composite materials

The traditional research methods of composites mainly focus on experiment and theoretical modeling, and gradually form a research method in which experimental observation, analytical modeling, and numerical simulation complement each other. However, the complexity of the composition and structure of composites puts forward new problems for the performance prediction, optimization design, molding, and manufacturing of composites. For example, the problems of multi-scale mechanical properties characterization of composites, accurate reverse structure design, and uncertainty propagation of composites can not be well solved under the framework of traditional experimental analysis, theoretical modeling, and topology optimization. The difficulties of traditional research methods, such as insufficient experimental observation, lack of theoretical model, limited numerical analysis, and difficult result verification, seriously restrict the rapid development of composite research for future applications.

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1.4 Research questions

1. Development of composite materials in the past.
2. Current situation and existing problems of artificial intelligence in composite materials.
3. How can the artificial neural network and the expert system solve the difficulties in the synthesis of composites.
4. How will the future composite materials develop by using artificial intelligence.

1.5 Research release

This paper will use the analysis and summary of the development process of composites to infer its development law and summarize the problems to be solved. Through the description and analysis of the working principle and essential structure of the artificial neural network and expert system, the solutions to the difficulties of artificial intelligence in composites are summarized. And through the current development of artificial intelligence and some successful examples of artificial intelligence in composite materials, the author can predict the future development path.

1.6 Research purpose and significance

Through the study of artificial intelligence in composites, the author can clarify the reasons for the application of artificial intelligence in composites and understand how artificial intelligence assists the synthesis and optimization of composites in detail. Through the research and summary of the full text, the development of artificial intelligence in the future can be speculated and predicted.

2. ARTIFICIAL INTELLIGENCE

2.1. Expert system

In 1969, American scientists first developed the DENDRAL expert system for determining the molecular structure formula of organic chemistry. With its accurate and exquisite expert level, it has been successfully and widely used in the chemical laboratories of industry and universities, which marks a milestone in the application of the expert system in materials, medicine, and chemistry.

The essence of an expert system is an intelligent computer program system, which stores a large number of human expert-level knowledge and experience in a specific field. It can solve specific problems in a specific field by simulating human experts' knowledge of dealing with problems and problem-solving methodology.

The following is the basic structure diagram of the expert system and the detailed function and operation principle of each part:

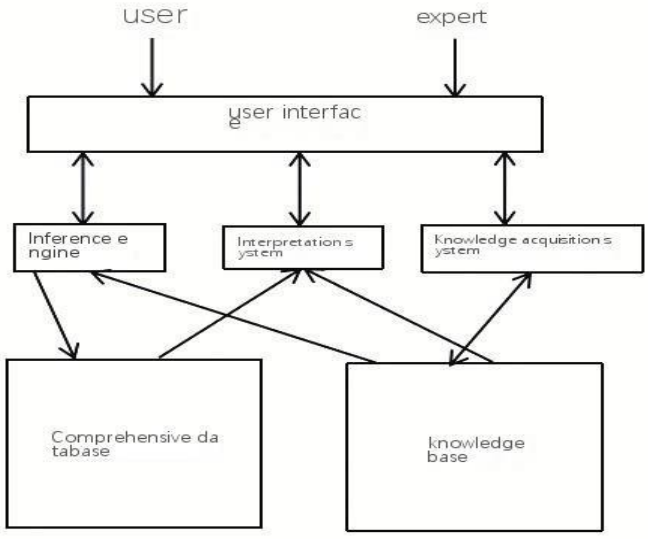

Figure 1. Basic structure diagram of the expert system and the detailed function and operation principle of each part

1. The knowledge base is used to store the knowledge provided by human experts, including fields Knowledge, historical data, mathematical models, etc.
2. Inference engine is used to control the whole system to decide how to use the knowledge base. It is the knowledge and rules in getting new knowledge.
3. The comprehensive database is used to store all the information required for the operation of the system. In terms of material design, it mainly includes the composition of materials and process parameters and performance parameters. In addition, it can also store images.
4. Explain the questions raised by the system for users through the backtracking reasoning process answer.
5. The knowledge acquisition system is used to update and modify the knowledge base.
6. The user interface realizes the interaction between the user and the system [3].

The technical threshold of the expert system for users is not high, and users do not have to understand the specific contents and reasoning ideas inside the system.

In the early stage of designing composite materials, because people were not clear about the internal microstructure of materials at that time, it was also

designed by experience. By simulating human thinking and reasoning strategies, the expert system solves the complex problems that human experts can complete. The expert system can store a large number of experimental data according to the knowledge system of material science, form a comprehensive database for reference, and form a knowledge base. After the expert system is introduced into the production and synthesis of composite materials, it not only connects artificial intelligence with the practical problems that need to be solved in the national economy and science and technology, resulting in huge economic benefits but also extends the ability of a few experts.

However, the expert system also has obvious deficiencies. The expert system is only based on the law and carries out logical reasoning through summary and induction, but it is not very clear about the relationship between the components, processes, and properties of specific different materials, and it only infers from the existing knowledge. If it encounters the knowledge that has not been encountered, it may not be able to draw a certain law. Due to the specificity of the expert system, there is often nothing to do with various problems.

To solve the above problems, the author has to mention artificial neural network.

2.2. Artificial neural network

The artificial neural network is a kind of artificial system that simulates the structural characteristics of a biological neural network using engineering technology. It uses nonlinear processing units to simulate biological neurons and uses the variable connection strength (weight) between processing units to simulate synaptic behavior, to form a large-scale parallel nonlinear system. Taking the BP algorithm as an example, the BP network can automatically solve reasonable rules by learning the case set with correct answers and has certain generalization abilities. Learning has the potential to be "solidified", but it is difficult to solve the contradiction between the actual scale of application problems and the scale of the network [4].

The most important thing is that it is different from the expert system. The artificial neural network has adaptability. It can upgrade itself through its continuous learning. It can also draw regular conclusions from the existing knowledge and obtain knowledge, and the whole learning process does not need external participation [5]. This feature makes it completely make up for the shortcomings of the expert system. The artificial neural network can predict the results of the problem from the existing material data parameters, enhance the weak learning ability and specificity of the expert system, and make it have the learning ability to constantly improve itself.

The following is the basic structure diagram of the artificial neural network:

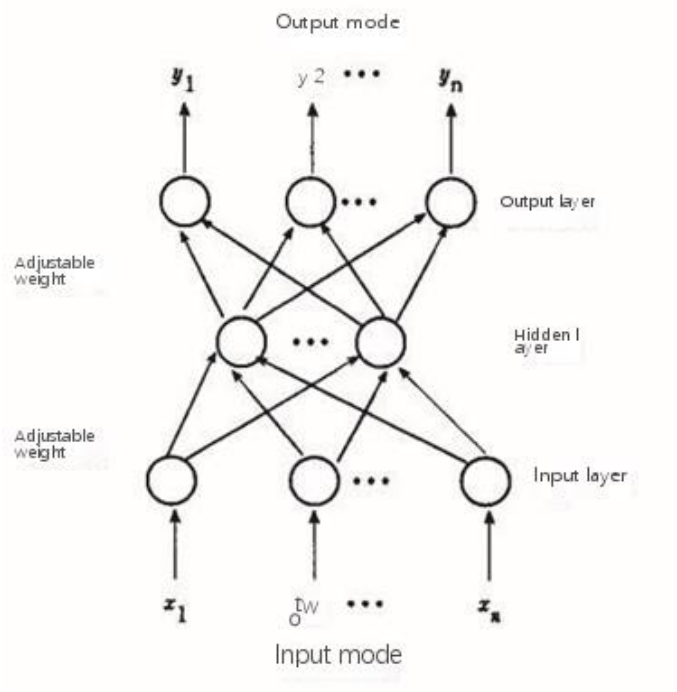

Figure 2. Basic structure diagram of the artificial neural network

With the rapid development of the artificial neural network, it is closely combined with modern science and technology. They cooperate mutally. In addition, it has high speed and potential ultra-high speed. It has the ability of fault tolerance. It is also suitable for solving problems that are difficult to find good solution rules (such as pattern recognition). The artificial neural network also has disadvantages. It is difficult to accurately analyze various performance indexes and apply them to the calculation of pursuing the correct answer [6].

Artificial neural network, after decades of long-term development from its proposal to present, has gradually become perfect in some aspects, and gradually formed a perfect and comprehensive technology, which has provided powerful help for the development of the times. In the future, with the development of hardware technology, the fragmentation and marginalization of cloud services, the intelligence, and the informatization of cities, the application of artificial neural network will be more and more, and the scope of application will become more and more extensive. The artificial neural network will play an indispensable role in the development of the times.

2.3. Combination of the two systems

With the rapid development of artificial intelligence technology, people apply the combination of the expert system and the artificial neural network to various industries. It also founded the synergetic artistic intelligence system, and then the system addeds more intelligent systems to complete the ability to simulate human brain functions in all aspects [7]. The idea of Synergetic Artificial Intelligence has integrated the essence of the expert system and the artificial neural network principles and has filled the original shortcomings. It can coordinate each part to solve the problem of processing and get the best solution in more complicated cases.

The synergetic artistic intelligence system has the following characteristics:

1. Intelligent online processing of information optimizes the material production process by making full use of a large amount of knowledge collected online.

2. As the collaborative artificial intelligence system is the integration of multiple intelligent technologies, it can simulate the human brain in an all-arounded way and replace some mental activities in the actual production operation control link.

3. The combination of intelligent optimization and numerical simulation enhances the application of knowledge in intelligent optimization It improves the accuracy of the control system and improves the system Quality.

3. APPLICATION

The most important application of artificial intelligence to modern composites is aerospace. With the development of the aerospace industry, higher requirements are put forward for material properties.

The characteristics of artificial neural networks mentioned above are nonlinear, so they are very suitable for dealing with complex multi-dimensional nonlinear problems. High Co-Ni secondary hardening steel is such a system. Therefore, the artificial neural network and backpropagation algorithm (BP) are used to build a data model to predict the mechanical properties of High Co-Ni secondary hardening steel with different alloy content [8], to improve the toughness and strength of high Co-Ni secondary hardening steel under the optimal condition.

Graphene, as a new 2-dimensional carbon allotrope, has a molding technology. Optimizing the process parameters of graphene nanocomposites to remove heavy metals from polluted water and coordinating the adsorption process conditions can effectively improve the adsorption efficiency of heavy metals in polluted water. Combining artificial neural network with genetic algorithm and particle swarm optimization algorithm, artificial neural network genetic algorithm (ANN-GA), and artificial neural network particle swarm optimization (ANN-pos) are obtained [9]. This method can achieve local optimization by comparing adjacent particles, then form the optimal particle swarm, and finally find the extreme value of all adjacent optimal particles to achieve global optimization, maximize the adsorption efficiency of graphene, and finally realize its wide practical application in sewage treatment engineering.

Since tire rubber is a mixture of more than 15 materials such as natural rubber, synthetic rubber, and carbon black, its development process is very complex and has different properties, which depends on various variables, including temperature, equipment, combination sequence and pressure, and the combination proportion of each material. It usually takes six months to three years to develop a new composite, but if artificial intelligence is used, this time is expected to be reduced by 50%. Hentai tire said that it has developed a prediction model - virtual composite design (VCD) system to use the tire composite characteristics of artificial intelligence, which will shorten the development cycle of new composites by 50%. According to the company, the technology used in the VCD system can predict the characteristics of composites and obtain the best combination of materials through artificial intelligence analysis [10], which is based on accumulated data that has not been tested during tire data development.

Similarly, based on genetic algorithm and computer programming method, the engineering optimization can be carried out for the laying quantity, laying proportion of each angle, and laying sequence of composite laminate [11]. Through this method, when the laminate laying material is selected, the available solutions of laminate engineering can be quickly obtained and sorted. In different ply combinations, the ply combination with the largest laminate strength value can be easily selected to complete the ply optimization. Compared with the traditional manual calculation method of laminate strength value, the calculation efficiency is greatly improved.

4. CONCLUSION

In recent years, with the continuous development of artificial intelligence technology, new ideas and methods have been provided for researchers in many traditional research fields, such as biology, medicine, geophysics, and so on. In the field of composite materials, artificial intelligence methods are also booming. The prediction of material properties based on the artificial intelligence method has gradually formed a mature paradigm based on experimental results, generating data sets by numerical simulation method and modeling and prediction by artificial intelligence method.

In the future, the research on the design and optimization of composites based on artificial intelligence theory has two development directions: one is to select a reasonable method to obtain a more accurate design model according to the actual subject; second is to expect more reasonable and accurate optimization model method. Of course, the research of material design with the intelligent method can not replace the traditional experimental research after all. The combination of theory and experimental methods will be the development path of material design in the future.

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