GA-BP Optimization Using Hybrid Machine Learning Algorithm for Thermopile Temperature Compensation

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ABSTRACT

Thermoelectric pile, which uses non-contact infrared temperature measurement principle, is widely used in various precision temperature measuring instruments. This paper analyzes environmental temperature's influence on thermoelectric piles' measurement accuracy and proposes a environment temperature compensation based on GA-BP (Genetic Algorithm-Back Propagation) neural network. The GA algorithm makes up for the slow iterative speed and easy to fall into local optimization of BP algorithm. The experimental simulation results show that environment temperature compensation based on GA-BP can accurately correct the measurement error caused by environmental temperature and other factors.

KEYWORDS

Environment Temperature Compensation, GA-BP Algorithm, Thermoelectric Piles

INTRODUCTION

As a non-contact infrared temperature measurement device, thermopile is widely used in various fields (Xu et al., 2022). However, the temperature measurement accuracy of thermopiles is often affected by changes in ambient temperature, which leads to inaccurate temperature measurement results. In order to solve this problem, researchers have proposed a method to optimize the design of the thermopile ambient temperature compensation algorithm using a genetic algorithm-backpropagation neural network (GA-BP) (Ding et al., 2011).

GA-BP is an optimization algorithm that combines genetic algorithm and back propagation neural networks (Mehboob et al., 2016). Genetic algorithm gradually optimizes the problem-solving

DOI: 10.4018/IJITWE.337491 *Corresponding Author

ability by simulating the process of biological evolution, based on the gene combinations of optimal individuals in a population, using operations such as selection, crossover and mutation (Yang et al., 2014). The back propagation neural network, on the other hand, is a commonly used artificial neural network model with powerful learning and approximation capabilities (Chen & Wang, 2021).

Traditional back-propagation (BP) neural networks have some shortcomings in dealing with complex problems, such as easily falling into local optimal solutions, slow training speeds, sensitivity to initial weights and thresholds, and easily overfitting (Shi et al., 2023). To overcome these problems, we use a hybrid method that incorporates genetic algorithms and BP neural networks (the GA-BP method).

The GA-BP method effectively improves the performance and stability of traditional BP neural networks by taking advantage of the genetic algorithm's global search capability, stable parameter initialization, accelerated network convergence speed, and reduced risk of overfitting (Han et al., 2021). First, the structural parameters and initial weights and thresholds of the network are determined by a genetic algorithm to improve the generalization ability and convergence speed of the network. Then, during the training process, the weights and thresholds of the neural network are further optimized by a combination of genetic manipulation and backpropagation to obtain better performance (Moisello et al., 2022).

In the study, the GA-BP method was found to have significant applications in dealing with the modelling and solving of complex problems. It provides researchers with an effective tool and method for data mining, pattern recognition, predictive analytics, and other fields. As the GA-BP method makes full use of the respective advantages of BP neural networks and genetic algorithms, it can search for the optimal solution in the global range and improve the performance and stability of the network through the optimization operation of genetic algorithms.

In designing the ambient temperature compensation algorithm for the thermopile, the researchers first built a neural network model containing an input layer, a hidden layer, and an output layer. The input layer receives the original temperature data from the thermopile, the hidden layer processes and converts the data, and the output layer gives the corrected temperature data. Then, the weights and thresholds of the neural network are optimized by the GA-BP algorithm to minimize the influence of ambient temperature changes on the temperature measurement results (Wang & Xie, 2016).

Using GA-BP to optimize the design of the ambient temperature compensation algorithm of the thermopile has the following advantages: first, through the global search ability of the genetic algorithm, a better combination of parameters can be found, which improves the effect of the compensation algorithm. Second, the back propagation neural network can learn and fit according to the input training samples, which makes the compensation algorithm more accurate and stable. Finally, the optimization method can be adapted to the temperature measurement needs under different ambient temperature conditions, which has a certain degree of universality and flexibility (Shubha & Shastrimath, 2022).

The GA-BP optimization design of the ambient temperature compensation algorithm for thermopiles can improve the temperature measurement accuracy of thermopiles and reduce the influence of ambient temperature changes on the temperature measurement results. This will bring important application value in many fields, such as industrial production, medical diagnosis, and energy management (Han et al., 2021). Future research work can further explore the improvement of the optimization algorithm and the expansion of the application areas to meet the requirements of temperature measurement accuracy of thermopiles in different fields.

The GA-BP algorithm proposed in this paper is a hybrid method that combines the BP neural network algorithm with the GA genetic algorithm. By leveraging the strengths of the GA genetic algorithm, the limitations of the BP neural network algorithm in weight are compensated for, improving the mapping ability and generalization of the BP neural network algorithm and enhancing its convergence speed.