Prediction and Analysis of Water Requirement for Strawberry Growth

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Abstract. With the rapid development of artificial neural network, its application in agricultural Internet of Things has become more and more widespread. In this paper, the effects of temperature, humidity and light intensity on water requirement of strawberry growth were analyzed. Temperature includes soil temperature and air temperature, and humidity includes soil humidity and air humidity. The BP neural network is optimized based on genetic algorithm, and the network topology is 5-11-1. Then the algorithm model is realized by using MATLAB. After verification, the predicted value of the model is basically consistent with the actual value of strawberry water demand, and the absolute error is within (0,0.18), which is a reasonable range.

Introduction

With the current shortage of water resources in the world, water conservation has become a key issue. In agriculture, because of the need to irrigate agricultural crops, the amount of water required is very large. How to save water and precise drip irrigation has become a major research direction. The rise and development of artificial intelligence provides people with another perspective to solve problems. Han Yu⁵ introduced the application of artificial intelligence in pre-production, mid-production and post-production of facility agriculture, and the development prospects of artificial intelligence. Xie Dong⁶ and others introduced the research of neural network in crop yield prediction and pests and diseases, and proved the possibility of neural network application in agricultural prediction. Yang Fanni¹ combined genetic algorithm and BP neural network algorithm to accurately predict the water requirement of cucumber. She considered the influence of different seasons on the water demand of cucumber, but the difference in temperature caused by different regions and the water demand were different.

Model Establishment of Strawberry Water Demand Prediction

The amount of water required for the different stages of strawberry growth is different, so we need to accurately drip it. In his paper, Yang Fanni gave the water demand and the temperature and humidity of the air, and the light intensity is exponential. This paper combines the local environment, taking into account the temperature and humidity of the soil, and uses them as input parameters to establish the 2-1 type. Output prediction model:

\[ Y = A \exp(BX_1 + CX_2 + DX_3 + EX_4 + FX_5) \]  \hspace{1cm} (2-1)

Among them, in the 2-1 formula, \(X_1, X_2, X_3, X_4, X_5\) Corresponding to the temperature of the air, the humidity of the air, the temperature of the soil, the humidity of the soil, and the intensity of the light, the coefficients \(A, B, C, D, E,\) and \(F\) vary with the seasons, and this paper is only in the winter. The test data in the environment, combined with the formula given by Huang Hongxia⁷, can be pushed to the range of \(A (0, 1)\), the range of \(B\) and \(D\) is \((0.1, 0.2)\), and the range of \(C\) and \(E\) is \((-0.5, -0.1)\), the range of \(F\) is \((2, 4)\). By collecting the corresponding data in the sensor and cleaning the data. Then use BP neural network module in MATLAB to analyze the data.
Because BP neural network has slow convergence rate and local polarization problem, it is necessary to use genetic algorithm to optimize BP neural network algorithm.

The BP neural network is a learning algorithm suitable for multi-layer neural networks based on gradient descent under the guidance of a mentor. Figure 1 shows the structure of a BP neural network.

By combining genetic algorithm and BP neural network algorithm, the model is used to predict water demand. The basic idea of algorithm implementation is to first perform genetic operations and then BP algorithm for optimization. That is, the initial population is randomly generated, the population is optimized by genetic algorithm, and the network is cyclically trained until the transformation condition with the BP algorithm is reached. Then, the population optimized by the genetic algorithm is decoded and used as the initial weight, and the BP algorithm is used. Then optimize the weight, and also train the network cyclically until the target error of the network meets the accuracy requirements.

The flow chart of BP neural network algorithm based on genetic algorithm is shown in Figure 2:
In the BP neural network, the number of hidden layers is selected as a single hidden layer network; usually, the number of neurons in the hidden layer is $2N + 1$, and $N$ is the number of input neurons, so the number of neurons in the hidden layer is 11. The establishment of the genetic algorithm parameters is selected using real coding; the selection operator is determined by the selection probability $2-2$

$$p_k = \frac{f_k}{\sum_{i=1}^{p} f_i}$$

(2-2)

In Equation 2-2, $f_k$ is the fitness of individual $i$; the crossover operator is determined by the crossover probability $p_c = 0.6$; the mutation operator is determined by the mutation probability $p_m = 0.05$; the population size is $M=20$, and the genetic inheritance is $G=10$.

Results and Analysis

The model was simulated in MATLAB, and the input vector was 5, corresponding to air temperature and humidity, soil temperature and humidity and light intensity, and the output vector was the water requirement of strawberry. 70 sets of data were selected, 40 of which were used as training data, and the remaining 30 sets of data were used as test data, the data was scrambled, and data was randomly selected to ensure the representativeness of the data. It can be obtained from the input vector and the input vector. The topology of the model is 5-11-1. The default state is selected for the hidden layer and the output layer. The neural network is constructed by the newff function in MATLAB, and the data is normalized by the mapminmax function. And set the maximum number of learning times of the network is 1000 times, the mean square error is 0.00003. Firstly, the genetic algorithm optimizes, and the obtained optimal weights and thresholds are assigned to the BP neural network, so as to obtain the predicted results of the strawberry water demand below.

Figure 3 is the prediction of strawberry water demand based on BP neural network model based on genetic algorithm, and Figure 4 is the prediction result of BP neural network algorithm. The expected output is the actual output. It can be seen from Figure 3 that the output of the strawberry in the water demand sample 2 to the sample 3 is rising, and the expected output is rising, but from the overall perspective, the change law of the two is basically the same. In Figure 4, the BP neural network training results in a larger variation of the predicted output and the expected output, mainly between the sample 20 and the sample 25. The expected output is generally an upward trend, and the predicted output is first decreased. In addition, in sample 29 to sample 30, the rate of change of the BP neural network is much larger than that of the GA-BP neural network algorithm model. Therefore, the fitting effect of the BP neural network algorithm model based on genetic algorithm is ideal, as shown in Figure 4.

![Figure 3. Predictive output and expected output of GA-BP.](image1.png)

![Figure 4. Predictive output and expected output of BP.](image2.png)
Figure 5 is the absolute value of the BP neural network algorithm model based on the genetic algorithm for the strawberry water demand forecast output and expected output. Figure 6 is the absolute value of the BP neural network algorithm for the strawberry water demand prediction output and expected output. It can be seen from Figure 5 that the absolute value of the GA-BP network prediction error is between (0, 0.18), and only the absolute value of the error of the sample 2, 8, 10 is greater than 0.1, and the absolute value of the remaining error is (0, 0.1). It can be seen from Fig. 6 that the absolute values of the two errors obtained by the BP neural network have reached 0.3 at the time of sample 5, and the error value between samples 20 and 30 is preferably 0.9, and the values are all greater than 0.2, and the error is larger. Therefore, BP neural network algorithm training data optimized by genetic algorithm is more advantageous than BP neural network algorithm training data.

Four Conclusions

1. In Heilongjiang, the cultivation of strawberries in winter has a close relationship with the environmental factors in the greenhouse. It is necessary to study not only the light intensity, the temperature and humidity of the air, but also the temperature and humidity of the soil.

2. Through experiments, the BP neural network algorithm model based on genetic algorithm optimization established in this paper can achieve the accuracy and error of data requirements. Therefore, the application of this model to the prediction of strawberry water requirement is relatively reliable and accurate.

3. Considering that the weather in Heilongjiang is relatively cold, the research results have important guiding significance for the study of strawberry water requirement in greenhouse.

References

[1] Yang Fanni. Construction of Intelligent Prediction System for Water Saving Irrigation [D]. Kunming University of Science and Technology, 2017.

[2] G.E. Jiankun, Li Xiaoping, Luo Jinyao. Prediction Model of Eggplant Transpiration Rate under Drip Irrigation in Greenhouse Based on BP-NN [J]. Water Saving Irrigation, 2016(08): 95-98.

[3] Qin Cong. Effects of drip irrigation minimum on soil moisture and apple saplings in orchard [D]. Taiyuan University of Technology, 2016.

[4] Qin Cong. Effects of drip irrigation minimum on soil moisture and apple saplings in orchard [D]. Taiyuan University of Technology, 2016.

[5] Han Yu. Application of artificial intelligence in the field of facility agriculture [J]. Agricultural Engineering Technology, 2016, 36 (31): 44-47.

[6] Huang Hongxia. Research on Decision Support System for Greenhouse Crop Irrigation Volume [D]. Jiangsu University, 2005.