Analysis of Light and Light Quality Control of Greenhouse Strawberry Based on BP Neural Network

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Abstract. With the demand for agricultural output value, there is an increasing demand for artificial intelligence in agriculture. In this paper, the red strawberry is taken as an example. The problem of the good yield value of strawberry cannot be accurately controlled in the greenhouse in the north. Combined with BP neural network, the neural network algorithm is optimized. The neural network is constructed by using tensor flow to substitute the data for one hundred trainings. The accuracy is obtained, and the structure obtained after simulation is effective. Through our improved control process, strawberry is optimally controlled in terms of illumination, photoperiod and light quality, so that strawberry can also achieve high yield and high quality in the north.

Introduction

Strawberries are currently more popular in China. The general colonization period of strawberries is in September, but due to the short sunshine time and low temperature in Northeast China, which is not suitable for strawberry growth. How to improve the production quality of crops has become the focus of current agricultural work. Neural network technology is a manifestation of current agricultural informationization and precision [1]. Li Yingxia [2] and others have shown that through the neural network control algorithm, the intelligent control and the traditional control and methods can be combined to make the greenhouse control system develop in the direction of automation, intelligence and unmanned. Zhang Minghong [3] and others showed that different photoperiods have different effects on strawberry growth, and Hong Jianping [4] and others proved the performance of BP neural network and the effectiveness of illumination prediction. Therefore, by using BP neural network to train its optimal value, we have achieved good control of photoperiod, light intensity and light quality in the greenhouse, and promote the high yield, high quality, self-production and self-sale of strawberry to reduce costs.

Research Method—BP Neural Network Algorithm

The BP network is a unidirectional forward multi-layer forward network. It is a neural network with three or more layers, including an input layer, an intermediate layer (hidden layer), and an output layer. A full connection is achieved between the upper and lower layers, and there is no connection between each layer of neurons. When a pair of learning samples is provided to the network, the activation values of the neurons propagate from the input layer to the output layer through the intermediate layers, and the neurons in the output layer obtain the input responses of the network. Next, according to the direction of reducing the target output and the actual error, each connection weight is corrected layer by layer from the output layer through each intermediate layer, and finally returns to the input layer. As the error correction of this error inverse continues, the correct rate of response of the network to the input mode is also increasing. The data prediction problem of the general mode can be solved well by the three-layer network. The BP three-layer network structure is shown in Figure 1.
The output of the \( j \)th neuron node of the hidden layer is:

\[
y_j = \phi(\text{net}_j) = \phi(\sum_{j=1}^{M} W_{ij} X_j + \theta_j)
\]

The output of the \( k \)th neuron node of the output layer is:

\[
O_k = \psi(\text{net}_k) = \psi(\sum_{i=1}^{q} W_{ki} y_i + a_k) = \psi(\sum_{j=1}^{M} W_{kj} X_j + \theta_k) + a_k
\]

In the backpropagation process, all sample quadratic error criterion functions are:

\[
E_p = \frac{1}{2} \sum_{k=1}^{l} (T_k - O_k)^2
\]

The output layer weight formula is:

\[
\Delta W_{ki} = \eta \sum_{p=1}^{p} \sum_{k=1}^{l} (T_k^p - O_k^p) \cdot \varphi'(\text{net}_k) \cdot y_i
\]

The output layer threshold formula is:

\[
\Delta a_k = \eta \sum_{p=1}^{p} \sum_{k=1}^{l} (T_k^p - O_k^p) \cdot \varphi'(\text{net}_k)
\]

The implicit layer weight formula is:

\[
\Delta W_{ij} = \eta \sum_{p=1}^{p} \sum_{k=1}^{l} (T_k^p - O_k^p) \cdot \varphi'(\text{net}_k) \cdot \phi'(\text{net}_i) \cdot X_j
\]

The implicit layer threshold formula is:

\[
\Delta \theta_i = \eta \sum_{p=1}^{p} \sum_{k=1}^{l} (T_k^p - O_k^p) \cdot \phi'(\text{net}_i) \cdot \phi'(\text{net}_i)
\]

**Greenhouse Lighting Control System Design**

We trained through the BP neural network model, and through repeated training, we obtained the illumination conditions when the target was optimal at different stages of strawberry growth. Finally, the fill light is controlled.
Analysis of Light Source Prediction Results

Using tensor flow to make the simulation model results, a strawberry with an area of 10m$^2$ is used as the experimental object, and the input layer object is set to $n=3$, and the input value is set to the light intensity, photoperiod and fill light required by the strawberry at different times. The quality ratio, the output value is the indicator of the pros and cons of the strawberry. Number of neurons in the hidden layer $n_2= 2* n_1+1 = 7$, the number of neurons in the output layer is 1.

The network is trained by tensor flow, the training frequency is 100, the learning rate is 0.2, the training target is actual and prediction error, and the error value is 0.0001. The training results are shown in the figure. Figure 3 shows the result that the prediction error decreases with the increase of the number of trainings. The neural network is constructed with tensor flow, and then the training data is brought into training for one hundred times. After each training, the test data is brought into
the test. The model finds the accuracy and then derives the accuracy of the model after each training. We can see from the figure that the error drop is most obvious between 0 and 20 training sessions. As the number of training increases, the error value begins to approach zero. Figure 4 shows the distribution of 100 training errors. The test data is substituted into the model after one hundred trainings. The predicted value is subtracted from the actual value and the absolute value of the difference is distributed. Most of the errors are concentrated between 0 and 0.2. It shows that through the training of BP neural network, the error of data is getting smaller and smaller, which can more accurately predict the optimal value of the external conditions required for strawberry growth. From this result, we should know that in the strawberry seedling stage, we should increase the proportion of blue light by 15 hours per day. Increase the proportion of red light in eight hours of light per day during flower bud differentiation. At the beginning of the growth period, the red light is still the main source, and the blue light is supplemented. The bud period and the result period are filled with red and blue ratios of 4.9:1. Through the control system and the data predicted by the BP network, the strawberry is more sweet and delicious, and the fruit is huge.

![Image](image.png)

**Figure 3. Neural network model error.**

**Figure 4. Error Distribution Histogram.**

**Conclusion**

In this paper, BP neural network algorithm is used to obtain the optimal parameters to achieve the optimal light intensity, photoperiod and light quality of strawberry, and the high output value and high quality have been achieved.

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**References**


