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Plant Factory Data Processing based on Deep Learning Algorithm

Chen Jie-Jie

School of Automation and Electrical Engineering, Tianjin University of Technology and Education, Tianjin 300222, China

Abstract: ***The plant factory belongs to an emerging "smart agriculture" product, which not only has broad development prospects, but also has important research significance. In the background of plant factory research, the hydroponic lettuce in the plant factory was taken as the research object, and an embedded development platform based on Raspberry Pi was built to realize the real-time monitoring of the plant factory control system. Lettuce related feature information, using machine learning algorithms, for data processing and research. The platform has certain guiding significance for predicting the optimal growth environment parameters of hydroponic lettuce, finding the optimal environmental parameters suitable for plant growth, and improving the quality of lettuce.***

Keywords: Plant factory; embedded; deep learning; hydroponic lettuce**.**

1. Introduction

The concept of the plant factory was first proposed by Japan and was interpreted as a system for continuous crop production through high-precision environmental control in the facility. Denmark created the world's first plant factory in the 1950s and 1960s [1, 2] . The plant growth cabinet is essentially a micro-plant factory that achieves continuous production by controlling the environment within the facility. In the whole system, it includes soilless cultivation technology, light control technology and environmental control technology. In recent years, with the development of deep learning, deep learning related algorithms have been gradually applied to various fields in plant factories, such as machine vision extraction of plant leaf area information, detection of fruit maturity, etc. [3]. In this paper, through the deep learning algorithm, the important relationship between the environmental parameters inside the plant and the hydroponic plant growth characteristics (plant height, leaf width) is analyzed, and a mathematical model of environmental parameters and plant characteristics is established by algorithm to adjust the environment. Parameters, optimization of plant plant control systems, and improvement of plant growth quality are of great significance.

2. Neural Networks

2.1 Artificial neural networks

As one of the important branches of deep learning, artificial neural network is characterized by: a large number of artificial neurons are connected through a wide range, and a single neuron essentially belongs to a tiny neural network, between neurons and neurons. The network composed of connections is not only used to transmit information and feedback information, but also to continuously update neurons through forward propagation and back propagation, and finally form an optimal mathematical model. For artificial networks, multiple implicit layers of neural networks are also known as deep learning [4].

2.2 BP neural network

According to the function and effect of artificial neural network, it can be divided into feedforward neural network and feedback neural network. BP neural network belongs to a feedforward neural network, and its neuron signal is forward propagation. In the network structure of BP neural network, it consists of input layer, hidden layer and output layer. The core idea is to continuously adjust the weight to minimize the total error of the network, and finally realize the error of the actual output data and the expected output result. In the process of correcting the weight, the direction of error transmission is backpropagation. Therefore, BP neural network is an artificial neural network for signal forward propagation and error back propagation [5]. Its network structure is shown in Figure 1:

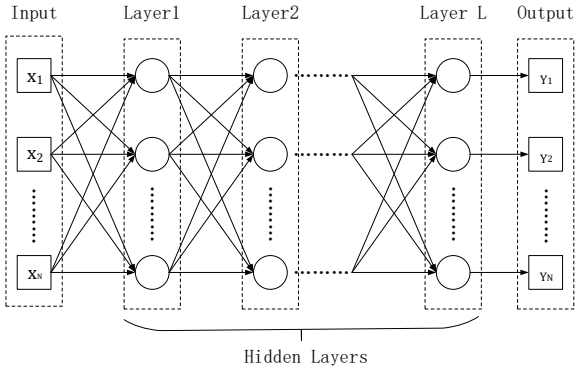

Figure 1: Neural network model structure

For a single neuron, its structure can be represented by Figure 2:

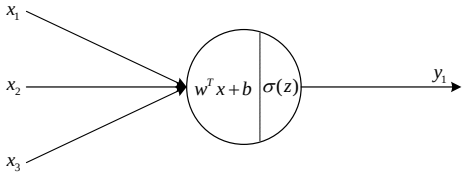

Figure 2: Single neuron structure

Where x_1, x_2, x_3 are the input data, w^T is the matrix of weights, b is the threshold, $\sigma(z)$ is the excitation function, y_1 is the output of the neuron, and in the logistic regression the circle of a single neuron represents a two-step calculation, while BP neural network That is, multiple logistic regression

operations are performed. There are five main steps in the construction of BP neural network:

1. Data normalization. Data normalization (normalization) processing is a basic work of data mining. Different evaluation indicators often have different dimensions and dimension units [6], which will affect the results of data analysis. In order to eliminate the dimension effect between indicators, data standardization processing is needed to solve the comparability between data indicators. After the data is standardized by the data, each index is in the same order of magnitude, which is suitable for comprehensive comparative evaluation. -max normalization, that is, standardization of dispersion, which is to linearly change the original data, and finally map the result in the interval [0,1]. The formula is as shown in formula 1, where x^* is the standardized data. x is the input raw data, and x_{min} and x_{max} are the minimum and maximum values of the input data.

$$x^* = \frac{x - x_{min}}{x_{max} - x_{min}} \quad (1)$$

2. The network model is constructed, that is, the network structure is determined, including the input layer, the hidden layer, and the number of output layers. The excitation function of the hidden layer generally adopts the following two types, namely, a sigmoid function and a Relu function, and the two activate function formulas such as formulas 2 and 3. Shown as follows:

$$\sigma(z) = \frac{1}{1+\exp(-z)} \quad (2)$$

$$\sigma(z) = \max(0, z) \quad (3)$$

3. Define the training function; include all parameters of the network (such as learning rate, number of iterations), loss function, etc.; BP neural network is characterized by the characteristics of error back propagation, when there is an error between the final output of the neural network and the actual value, The error signal is back propagated back and the associated weights and thresholds are modified during propagation until the desired output value is reached. The loss function is generally selected as the MSE (mean square error) function, also known as the objective function, which can be used to estimate the degree of inconsistency between the predicted value and the true value, and measure the effect of w and b on all training sets. The formula is as follows (4) shown:

$$J(w,b) = \frac{1}{m}\sum_i (\hat{y} - y)_i^2 \quad (4)$$

4. Define a test function;
5. Training and testing;

3. Development platform design

3.1 Embedded hardware design

This paper takes the intelligent plant growth cabinet of Tianjin Vocational and Technical Normal University as the research object. The growth cabinet is an intelligent plant growth control system based on LED light source, which not only realizes the light intensity, temperature, humidity, carbon dioxide concentration of the environment in which the crops grow. The control of the temperature of the nutrient solution also has the advantages of small volume and low operating cost. The control system is mainly composed of a main control unit control system, a sensor system, an execution unit system and an artificial light source control system, wherein each system uses an embedded chip as a core microprocessor, and the main control system unit control system and other subsystems The transmission of data and instructions via fieldbus technology ensures the reliability of data transmission, reducing the complexity of multi-threaded connections and unnecessary circuit interference [8,9].

3.2 Software design

In order to realize the plant growth process is considerable and controllable, it is convenient for the managers of the plant growth cabinet to timely and accurately monitor the growth of lettuce in the plant growth cabinet. The Raspberry Pi is used as the development platform of the host computer, and a remote monitoring platform based on wifi technology is established. The platform can not only monitor the growth status of hydroponic lettuce in the growth cabinet in real time, but also store various environmental indicators (temperature, humidity, light, nutrient solution temperature, etc.) in the current small plant factory in real time, and store it in the mysql database for the later stage. Data processing provides data resources.

The host computer platform uses Raspberry Pi 3 Model B+ as the linux development platform hardware. Its advantage lies in the convenience of building a small server and providing great convenience for mysql storage. It can also be equipped with a high-definition camera via a reserved USB interface. In addition, the Raspberry Pi can be programmed in Python language, and the lower computer platform can communicate with each other through the serial universal bus, and the lower computer main control system and other subsystems are connected by bus. The overall design structure is shown in Figure 3:

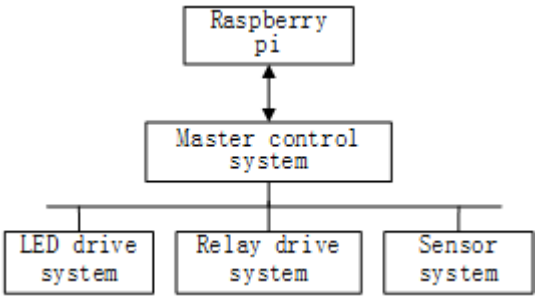

Figure 3: Overall design structure

4. Title, Authors, Body Paragraphs, Sections Headings and References

As one of the cultivation crops of intelligent plant growth cabinet, hydroponic lettuce can be evaluated by various parameters such as the size of lettuce leaf, the quality of lettuce and the length of lettuce stem. However, the parameters of plant growth environment are the final affecting plants. One of the important factors of quality, therefore, the temperature, humidity and nutrient solution temperature in the

intelligent plant growth cabinet are important factors influencing the growth trend of plants.

According to the deep learning network structure, the plant growth cabinet environment variable is taken as the input parameter, and the final morphological feature of the plant is the output parameter, and the network model is established. Take 200 sets of data, 150 sets of which are used as training data and 50 sets of data as test sets. After training, the training curve of the network is as shown in Figure 4 and Figure 5:

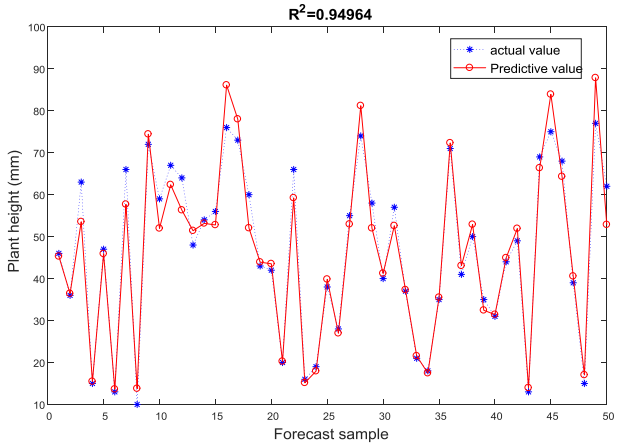

Figure 4: Plant plant height prediction result map

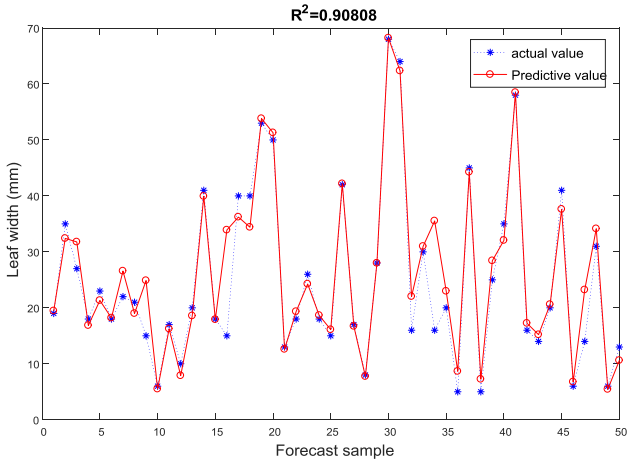

Figure 5: Plant leaf width prediction result map

5. Conclusion

The lettuce in the plant growth cabinet was used as the research object, and the growth state of lettuce was predicted by deep learning algorithm. The experimental results show that the model can effectively predict the growth characteristics (plant height and leaf area) of lettuce, according to the prediction. The results show that the accuracy of the test sets in Figure 1 and Figure 2 is 94.9% and 90.8%, but some data have some errors, such as the predicted data of lettuce plant height in [55,70], so the researchers can properly regulate the Environmental variables in the growth interval, optimizing the control system. The model can predict the growth of lettuce under more environmental conditions, so researchers can find the optimal environmental parameters suitable for plant growth based on the growth of lettuce and the input environmental variables, and improve the quality of lettuce.

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Author Profile

Chen Jie-jie, a graduate student, is currently engaged in research in the fields of artificial intelligence and machine learning.