Application of Intelligent Temperature Control Technology in Strawberry Greenhouse

Tao-tao SHEN¹, Yong-LIU¹, Yan-chao LI¹, Wei-tao QIAN¹, Xin-xin WANG¹, Wen-qing XIE¹, Chao-LI¹ and Hua-wei SUN²

¹College of Electronics and Engineering, Heilongjiang University, Harbin 150080, China
²Heilongjiang Eastern Water Saving Equipment Co., Ltd., Suihua 150000, China

*Corresponding author

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Abstract. China's greenhouse crop cultivation, flower cultivation and so on are still in a slightly backward stage. As a large agricultural country, it is very important to produce a thermostatic greenhouse with low price, strong environmental universality and stable performance. The development of artificial intelligence technology promotes the development of intelligent agriculture [1]. The agricultural expert decision-making system based on artificial intelligence technology improves the accuracy of agricultural knowledge acquisition and decision-making expression, and promotes the development of agriculture towards precision [2]. Therefore, it is very important to realize intelligent control of ambient temperature in order to meet the demand of growing environment in strawberry greenhouses. Based on the problem of temperature control, a fuzzy PID control method is proposed to realize the self-tuning of PID parameters and meet the requirements of PID parameters regulation in the temperature control process. In addition, compared with the conventional PID algorithm, the fuzzy PID algorithm has the characteristics of short rise time, fast response speed and high control accuracy. The fuzzy PID algorithm has good control performance on the temperature control system.

Introduction

Traditional PID controller, with its simple structure, good stability, reliable work, easy adjustment and other advantages of the main industrial and agricultural control technology. When the structure and parameters of the controlled object are uncertain, it is particularly convenient to adopt the fuzzy PID control technology when it is impossible to establish an accurate model.

Dai Junke et al. [3] designed and implemented an efficient temperature control system for LD based on self-tuning fuzzy PID algorithm in order to make the semiconductor laser (LD) work stably. The system USES self-tuning fuzzy PID algorithm and closed-loop negative feedback structure to realize the stable control of LD temperature. The experimental results show that the control system of temperature from 21.9 °C to rise to the target temperature 25 °C, and establish the steady time of 68 s, and the temperature can be controlled within the range 25 plus or minus 0.05 °C. Li Pei [4] high stability laser temperature controller based on PID algorithm. Aiming at the problem that the output wavelength and luminous power of distributed feedback (DFB) laser are affected by its operating temperature, the temperature control system is used to test the DFB laser with central wavelength of 1.742 microns. Experiment proved that the system control precision of plus or minus 0.05 °C, the temperature control range of 560 °C, and in the long run (220 min), DFB laser working state is stable, center wavelength does not appear drift. Niu Xiangjie [5] based on genetic algorithm control parameter tuning and its application in temperature control, in the beer production process, by determining PID parameters, to ensure accurate control of fermentation tank temperature. In view of the randomness of PID parameter selection in the field debugging process of fermenting tank temperature control, genetic algorithm was adopted to set PID parameter, and MATLAB and WINCC were online debugging based on OPC to achieve online setting and monitoring of data.
After the PID parameters adjusted by genetic algorithm, the rise time of the output response curve is 2.81s, the overshoot is 9.12%, and the adjustment time is 5.22s. The PID parameters of temperature control set by genetic algorithm have good effects, such as quick response, small overshoot, short adjustment time and satisfying the requirements of field control. Huang Zan et al. [6] combined fuzzy control and PID control to construct a fuzzy self-tuning PID controller, adjusted the parameters of PID controller online through fuzzy control rules, and elaborated the method of computer simulation of the controller in MATLAB.

The Working Principle of Intelligent Temperature Control System of Strawberry Greenhouse

Design Process and Requirements

Fuzzy PID intelligent temperature control system's main function is inside the greenhouse temperature real-time adjustment, due to different strawberries in the process of the growth cycle of growth appropriate temperature, through the sensor to collect the surrounding temperature and upload data to the server, according to the algorithm for online correction, constantly adjusting the parameters of the controller, make its reach the optimal value, so as to achieve the purpose of improving control system control performance.

The Basic Principle

PID control principle is simple and easy to implement, but its parameter setting is very troublesome. For the intelligent temperature control system of strawberry greenhouses, because it is a time-varying nonlinear system, different PID parameters need to be selected at different times, and the traditional PID controller is used, it is difficult to make the whole process have better operation effect. Fuzzy PID control [7], that is, the use of fuzzy logic and fuzzy rules for real-time optimization of PID parameters, in order to overcome the traditional PID parameters can’t be real-time tuning PID parameters shortcomings. Fuzzy PID control includes fuzzification, determination of fuzzy rules, fuzzy resolution and other components. The real-time temperature of the greenhouse is collected by the sensor to determine the deviation E of the current temperature and the change EC of the current deviation and the last deviation. Fuzzy reasoning is carried out according to the given fuzzy rules. Finally, the fuzzy parameters are decomposed and PID control parameters are output.

The Advantages and Disadvantages

For strawberry greenhouse temperature intelligent control system, the main advantages of embodied in the following aspects:

(1) The fuzzy PID control is according to the three parameters of PID controller and the deviation and deviation E fuzzy relationship between the change of the EC, constantly testing E and EC, at run time through a pre-determined relations, by using the method of fuzzy reasoning, modifying the three parameters of PID controller online, make the PID parameters self-tuning. (2) Because in the process of increment, the probability of error is low, when necessary can be judged by logic. For the unknown control algorithm, since the setting of the increment size is directly related to the deviation size, the system will not lose control of the integral when calculating the increment, which can promote the improvement of the adjustment effect. But the control system also has some shortcomings, mainly reflected in: (1) the integral truncation effect has a greater impact, mainly reflected in the static error. (2) When there is overflow phenomenon, it will have a greater impact on the size of the error.

System Design and Implementation

Controller Structure

It is shown in FIG. 1 that that adaptive fuzzy PID control structure is as shown in FIG. 1, based on the conventional PID control, adopt the concept of fuzzy reasoning, the variation rate of deviation E
and deviation of the controlled quantity is used as the input variable of two-dimensional fuzzy controller, the change value $K_p$, $K_i$, $K_d$ in the PID is the output, and the fuzzy control rule is used for on-line tuning PID parameter, in which the fuzzy control part includes the fuzzy and fuzzy inference calculation and the fuzzy theory.

![Fuzzy PID control structure.](image)

**Figure 1. Fuzzy PID control structure.**

**Identify Input and Output Variables**

Take deviation $E$ and deviation rate $EC$ as input of fuzzy controller, and change of PID controller $K_p$, $K_i$, $K_d$ as output. The adjustment formula of, is as follows:

$$K_p = K'_p + \{E, EC\}K_p = K'_p + \Delta K_p$$

(1)

$$K_i = K'_i + \{E, EC\}K_i = K'_i + \Delta K_i$$

(2)

$$K_d = K'_d + \{E, EC\}K_d = K'_d + \Delta K_d$$

(3)

The initial parameter of Type is $K'_p$, $K'_i$, $K'_d$ which is obtained by the general method. Set {NB, NM, NS, ZO, PS, PM, PB} as the fuzzy subset of input variable $E$ and $EC$, output variable $K_p$, $K_i$, $K_d$. The quantization domains of input variables $E$ and $EC$ are both $[-6, 6]$ and the basic and quantization domains of output variables $K_p$, $K_i$, $K_d$ and, are both set as $[-3, 3]$ and the scaling factors are both 1. Triangle function is distributed uniformly in the domain of theory, and its sensitivity is high.

**Establish Fuzzy Control Rules**

According to practical experience, the self-adjustment of parameters [8] $K_p$, $K_i$, $K_d$ under different $E$ and $EC$ conditions shall meet the following adjustment principles:

1. When the error $|E|$ is large, in order to enable the system to have better rapid tracking performance, no matter what the variation trend of the error is, a larger $K_p$ and a smaller $K_d$ value should be taken, and in order to avoid the larger overshoot of the system response, the integral effect should be limited and a smaller $K_i$ value should be taken.

2. When the error $|E|$ is in the medium large, in order to make the system response has a small overshoot, $K_p$ should be smaller, and at the same time to ensure the response speed of the system, and the size of $K_i$ and $K_d$ should be moderate. The value of $K_d$ which has a great impact on the system response.

3. When the error $|E|$ is small, in order to ensure that the system has good steady-state performance, $K_p$ and $K_i$ should take the larger, in order to avoid the system in the vicinity of the set value oscillation, and consider the anti-interference performance of the system, when the $|Ec|$ is smaller, $K_d$ can be the larger; When the $|Ec|$ is larger, $K_d$ should be smaller.

**Establish Fuzzy Reasoning System**

Fuzzy reasoning system editor and membership function editor with interactive graphical interface are used in MATLAB environment. According to the above results, parameters such as the theoretical domain scope of input and output fuzzy variables and the membership function shape of each language variable were selected, and the default centroid method was used to solve the fuzzy reasoning. After the definition of variables in the fuzzy reasoning system and the setting of membership functions of each variable were completed, the interface was shown in figure 2.
The design of fuzzy adaptive PID control requires the following steps:

1. Determination of fuzzy control rules. (Fuzzy control rules can be obtained mainly through expert experience and sampling data)

2. The membership degree of E (error) and EC (error rate of change) is obtained by fuzzy rule table.

3. Use the membership degree and the corresponding membership degree abscissa (e.g. PB, NS) into the formula to find out the $\Delta K_p, \Delta K_i, \Delta K_d$. The formula is as follows:

$$y = \frac{\sum_{i=1}^{n} \mu_{A_i}(x) \mu_{B_i}(y) Z_i}{\sum_{i=1}^{n} \mu_{A_i}(x) \mu_{B_i}(y)}$$

(4)

Where, $u_{A_i}(x), u_{B_i}(x)$ represents the obtained membership degree, and $Z_i$ represents the abscissa of the corresponding membership degree. (e.g. PB, NS)

4. By $K_p = K_p + \Delta K_p$ train set the parameters $K_p$, $K_i$, $K_d$ and into the PID controller operation.

PID formula is as follows:

$$\text{Output} = K_p e(t) + K_i \int e(t) dt + K_D \frac{d}{dt} e(t)$$

(5)

**Fuzzy PID Control Simulation**

According to the fuzzy PID control rules, MATLAB simulation is realized. Establish two inputs and one output, where the error, the rate of error change and the output are shown in the figure below.

**The Experimental Conclusion**

For lag, nonlinear controlled object adaptive fuzzy PID control method is proposed, the method combining fuzzy control and PID control combining the advantages of the two control methods, which can realize real-time online self-tuning of PID controller parameters, solves the large inertia in the process of temperature control of large amount of overshoot, slow response speed, the
problem of poor steady precision, the modeling and control methods to study the control law provides reference temperature environment simulation facilities.

According to the comparison of performance of different control methods and analysis of signal interference, it can be seen that the intelligent greenhouse temperature control system under the Internet of things has a high precision of temperature control and can be effectively applied to actual production activities.

Conclusion

With the economic development, agricultural production has unprecedented opportunities and challenges, how to make full use of agricultural resources, improve the market competitiveness of agricultural products, is to promote the development of agricultural production is a major problem. Greenhouse planting for the improvement of people's living standards has brought great convenience, has been rapidly promoted and applied. The intelligent monitoring system of agricultural greenhouses collects environmental parameters such as air temperature, humidity, illumination, soil temperature and soil moisture in the greenhouses in real time, makes real-time intelligent decisions according to the needs of crop growth, and automatically turns on or off the specified environmental regulation equipment. Through the deployment and implementation of this system, scientific basis and effective means can be provided for automatic monitoring of agricultural ecological information, automatic control of facilities and intelligent management. Thus, intelligent and refined modern agriculture can be realized.

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