Fuzzy-PID based heating control system

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1. Introduction

Many scientific devices have been used in Antarctica, and some parts of the device cannot run at the low temperature as low as -40 degree Celsius such as a mechanical tester in a scientific CCD opening[4]. In such a condition, a heating system should be designed to satisfy the temperature requirement. For a CCD camera, we designed a heater system for the phantom including a fast-bake shutter house, temperature sensor, heater, a control board based on STM32F103C8T6, heater driver and temperature sensor interface. A control software is also written in this computer.

Conventional PID has several problems, such as overshoot, low efficiency, poor environmental adaptability [3]. The fuzzy controller has a good control performance in multivariable, dynamic, nonlinear system. We put the temperature control system model, then simulate the whole system with the MATLAB's tools, and finally design a self-adapting Fuzzy-PID controller.

2. Heating Mode

The temperature to control input is the output of the target.

\[ T(t) = P(T(t)) \]

where \( T(t) \) is the heater power, \( T(t) \) is the output of the target.

With the latest tools of MATLAB, we can get the model of the target from these data. Then, we can use the Simulink to simulate the model, and evaluate its correctness.

![Simulink model of the heating system](image)

The PID controller is then used with integral and zero type of ideal model has the performance as high as 98.1%. And we can get the best fits as the model, it shown as follows:

\[ G(s) = \frac{1}{1 + 0.1s} \]

3. Algorithm design

As is shown in Figs. 3, the deviation value \( e(t) \) between the input signal \( u(t) \), which represents the target temperature and the feedback signal \( r(t) \) which is the current sample of the space temperature, is applied by two modules. One is the fuzzy controller, the other is the controller of the PID controller. The function of the fuzzy controller is to compute the parameters' modification values, which are used to automatically correct the integral parameter of the PID controller as \( K \) in (K), and via this, the PID controller calculates the control value \( u(t) \) output to controlled object, based on the feedback signal, is adjusted again to generate the close loop control.

![Fuzzy-PID control algorithm](image)

4. TEST RESULT

The heater is heated based on a high-precision temperature sampling board based on ADS1256 (CPLD, DAC).

The test result is shown in Fig. 5. The temperature control is shown in Fig. 6. When using Fuzzy-PID control, the heating target system has a lower temperature deviation and it takes the system shorter time to stabilize. In addition, Fuzzy-PID control has a strong adaptability in different environments, the performance of temperature regulation is reliable.

![Temperature control results](image)

![Temperature deviation](image)

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5. Conclusion

- Fuzzy-PID based heating control system has a lower temperature deviation and takes the system shorter time to stabilize. In addition, Fuzzy-PID control has a strong adaptability in different environments.