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Fuzzy-PID based heating control system

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Many scientific devices have been used in Antarctic, and some parts of the device can not run at the low temperature as low as -60 degree such as a mechanical shutter in a scientific CCD camera. 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 shutter including a heat-hold shutter house, temperature sensors, heater, a control board with fuzzy PID control for heater driver and temperature sensor sampling, a control software in the computer.

PID is the abbreviation of Proportional, Integral and Differential. PID control algorithm is widely used in the industrial process control algorithm for its attribute of simple structure, strong robustness etc. However, in the wide range of temperature span, there exists many problems such as a large oscillation amplitude, long time-consuming for stable. Moreover, the performance of the system greatly depends on the initial parameters of the algorithm.

The control algorithm we adopt is fuzzy PID control algorithm who is the combination of simple fuzzy control and PID control. When in the range of ±10℃ to the target temperature, the control algorithm is the fuzzy control algorithm. When below -10℃ to the target temperature, the duty cycle value is regulated by fuzzy control algorithm and secure control algorithm. It is the secure control algorithm that monitors the temperature and its variance rate on the MOSFET driver during the heating process and stops the change of the duty cycle value while each parameter exceeds their limits. When above +10℃ to the target temperature, an larger differential coefficient is put to use to accelerate the system response. The comparison between pure PID control algorithm and the control algorithm we adopt has been executed.

If the fuzzy control is used, the automatic setting of the control parameters of the PID algorithm, such as KP, KI, KD, can be realized. Thus, not only the advantages of the simple principle, easy to use and strong robust, but also the flexible and the better control accuracy is achieved. We tested the fuzzy control and conventional PID control. After the comparison between the two results, we find that the fuzzy PID control algorithm has the capacity to reduce the overshoot of the temperature, decrease the time consuming for stable and increase the accuracy of control. Different with the conventional PID control algorithm, the fuzzy-PID control algorithm owns a larger KP and smaller KI to reduce the range of the first overshoot during heating (the range of the first overshoot in conventional PID is about 2℃ and in Fuzzy-PID is about 0.7℃). During the subsequent automatic tuning, the algorithm continually gets the KI larger and the KP smaller, this makes less time consuming for temperature stable than conventional PID.

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