Application of Neural Network PID Controller in Small Medical Thermostat

Lei Xu, Liping Zhang, Zhikuan Cui, Caijun Xu
College of Electronic and Electrical Engineering, Shanghai University of Engineering Science, Songjiang District, Shanghai 201620, China
micro_yx@163.com, zhangliping@sues.edu.cn, cuizhikuan@sues.edu.cn, xucaijun@sues.edu.cn

Abstract: Based on the PID algorithm, internal analysis and detection technology of medical therotank and automatic temperature control requirements, determining a BP neural network PID control algorithm of intelligent control to achieve the effect of small medical therotank. This paper mainly introduces the design of software algorithm and implementation effect.

Keywords: Temperature control; Medical thermostat; Neural network; PID algorithm

INTRODUCTION

The rapid development of modern medical technology, medical devices, as its key technology research on the auxiliary also was quickly, manufactured to meet the needs of modern medicine, incubators for medical use is a good example. Smart thermostats are widely used in various fields, in medicine, biomedical incubator can be used for bacterial culture, Radioimmunoassay, serum dissolves, the paraffin melts, in vitro disinfection. Storage and transport of medicines, reagents, vaccines, blood-cold storage and insulation, dialysis fluid heating, heating with normal saline.

Emergency surgery, patients with hypothermia due to massive blood loss, but a lot of enzyme activity, State organs are affected, so attempt at openness rehydration process, you need liquid to heat to the proper temperature. At the same time taking into account the patient's heat loss from external links to prevent or to compensate for a sharp loss of body temperature, medical needs or patient experience is of great necessity.

MATHEMATICAL MODEL OF LIQUID HEATING

Based Commonly used in Physiology or clinical osmotic pressure equal to the animal or human plasma sodium chloride solution, concentration for amphibians are 0.67–0.70%, for mammals and humans is 0.85–0.9%. 0.9% sodium chloride and sterile water solution. The osmotic pressure and blood, and plasma sodium content similar to, but chlor ine content was significantly higher than that of plasma chloride content, so is more in line with normal saline physiological, and uses it to maintain fluid and electrolyte of the supply tension. In tense surgery patient body temperature decreased due to the loss of blood, and for autologous neural regulation are affected, it is difficult for body heat to make additional, and in clinical practice, a large number of external fluid flows will affect body temperature. Then it is necessary to human intervention in the temperature of the liquid in order to meet the requirements, for which we are taking saline as an example.

In the heating process of saline, the main source of heat from the semiconductors of incubator heating, and heat losses are mainly from absorption of heat.

Because of the precision of the controlled object, it is difficult to effect on variety of factors taken into account, for the more complex control object, we use mathematical models to make a qualitative description:

\[ y_{out}(k) = \frac{a(k)\text{out}(k-1)}{1+\text{out}^2(k-1)} + u(k - 1) \]  

In the formula, the coefficient \( a(k) \) is slow and time-varying. \( a(k) = 1.2(1 - 0.8e^{-k}) \)

NEURAL NETWORK PID CONTROLLER DESIGN

Based on neural network PID Tuning principles

The PID controller the result embodied in the proportional, integral, differential regulation over the three arguments, demanding its cooperation and mutual restraint in order to achieve the desired control objectives. Relationship but is simply a "linear combination ", it is difficult to find this relationship using traditional methods, and fill accuracy disadvantage of poor control and ability to express an arbitrary nonlinear neural network, so a combination will make the effect better.

BP neural network BP (Back Propagation) neural network is a group of scientists led by Rumelhart in 1986 and McCelland, is a kind of error back propagation training algorithm for the multilayer feedforward network, information processing system is composed of one or more neurons, the neural network model is one of the most widely used..BP network can learn and store a large number of input-output mapping relationship, without the need to reveal the mathematical equations describing the mapping relationship. The learning rule is to use the steepest descent method to adjust the weights and thresholds of the network by back-propagation. The topology of BP neural network model includes input layer, hidden layer and output layer. BP neural network block diagram is as follows:
BP-PID CONTROL SYSTEM DESIGN

Under the control effect of the conventional PID controller, the BP neural network is introduced, and its parameters are adjusted by using the adaptive and self-learning ability. Under the traditional linear controller:

\[ e(k) = r(k) - y \]  

The deviation is equal to the deviation between the given value and the actual output value of the controlled object. Can get output as:

\[ u(k) = K_p e(k) + K_i \sum_{j=0} e(j) + K_d [e(k) - e(k-1)] \]

Incremental PID control algorithm: the so-called incremental PID refers to the digital controller output is only the increment of control \( u(k) \). When the actuator is needed to control the amount of incremental, incremental PID control algorithm is derived to provide. Can be derived from the recursive principle:

\[ u(k-1) = K_p (k-1) + K_i \sum e(j) + K_d [e(k-1) - e(k-2)] \]

\[ \Delta u(k) = K_p [e(k) - e(k-1)] + K_i e(k) + K_d [e(k) - 2e(k-1)] \]

\[ = K_p \Delta e(k) + K_i e(k) + K_d [\Delta e(k) - \Delta e(k-1)] \]

in Formula: \( \Delta e(k) = e(k) - e(k-\) 

Formula (5) is called incremental PID control algorithm.

MATLAB SIMULATION AND ANALYSIS OF CONTROL EFFECT OF BP-PID SYSTEM

Assuming the approximate mathematical model of the controlled object:

\[ y_{out}(k) = \frac{a(k) y_{out}(k-1)}{1 + y_{out}^2(k-1)} + u(k-1) \]

In the formula, the coefficient \( a(k) \) is slow and time-varying. \( a(k) = 1.2(1 - 0.8e^{-0}) \).

Based on neural network structure selection, learning speed \( \eta = 0.28 \) and inertia coefficient \( \alpha = 0.04 \), the weighted coefficient of the initial interval \([-0.5,0.5]\) random number. Input command signal is unit step signal:

Fig. 2 Two performance index learning single neuron adaptive PID position tracking
Fig. 3 represents the control effect of BP-PID controller, fig. 4 shows the simulation results of PID control with stable boundary method, PID controller obviously uses the stable boundary method showed a transition time long shortcoming in the constant temperature box control, the neural network PID control is clearly reflect the control effect is excellent in overshoot and system transition time, as shown in a very short period of time will be able to achieve stability.

SUMMARY

In the study of small medical thermotank in the control effect of the BP neural network is introduced into the PID algorithm is obviously, when you need to heat the required liquid, is used in the system advantages of BP neural network PID control algorithm is reflected, of course in medical clinical practice for equipment requirement is stable and fast, constant temperature box which also makes small medical thermotank by BP neural network PID algorithm is better than the traditional promotion value.

References


