Research of Brushless DC Motor Simulation System Based On RBF-PID Algorithm

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***Abstract*—This paper has made a thorough analysis of Brushless DC Motor Simulation System, in which we use a single neuron PID control algorithm based on RBF neural network for on-line identification (RBF-PID Algorithm). A special human-computer interaction (HCI) interface was designed in this paper, which provides interface for users to set the correlative parameters and select related control algorithm. Two control algorithms: Conventional PID and RBF-PID Algorithm were respectively adopted in this paper to make a comparison. The result shows that RBF-PID Algorithm performs better controlling Brushless DC Motor. Thus, the Simulation System is of great advantage for parameters testing and setting for the controller of Brushless DC Motor compared with traditional manual methods in practical use.**

Keywords-Simulation System; Brushless DC Motor; HCI; RBF algorithm

1. INTRODUCTION

The PID controllers are widely used in the industrial process control because of their simplicity and robustness [1]. But conventional PID controller with fixed parameters can hardly adapt to time varying of characteristics in wide range. To improve the control performance, several tuning schemes of self-tuning PID controllers were proposed in the past [2][3]. However it is not easy to tune the PID parameters.

Radial Basis Function (RBF) network is powerful computational tools that have been used extensively in the areas of pattern recognition, systems modeling and identification. RBF network form a special architecture of neural network, which has advantages of the simplicity of its structure, faster learning algorithms, better approximation capabilities [4][5][6].

Brushless DC Motor, a kind of synchronous machine, has the properties of high running efficiency, high torque output at low speed, and high speed accuracy. Therefore it is widely applied in various aspects of industry. However BLDC is a controlled plant with the properties of nonlinear and strong coupling, so it requires higher for the control algorithm.

This simulation system, introduced in this paper, has a lot of advantages. A unique HCI interface has been provided to set parameters and display the real-time BLDC revolute speed waveform. The former improves the flexibility of RBF network so that the system could provide users a deeper realization of RBF-PID or Conventional PID algorithm. The latter makes it convenient to observe the BLDC motor running state. So the simulation system could meet any demands of users in the simulation procedure.

2. DESIGN OF MASTER MACHINE SOFTWARE

The master machine software is completed in the Visual Studio 2005 development environment. It provides a HCI interface with which it is easy to observe and record the BLDC motor operating condition. The HCI interface of master machine shows as Fig. 1.

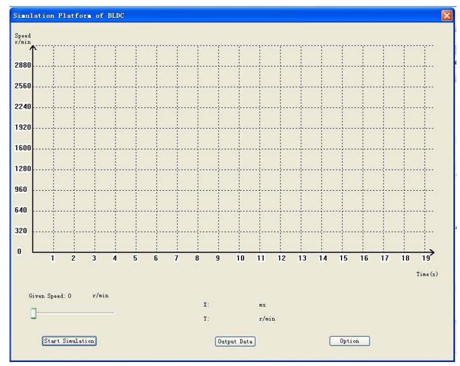

Figure 1. The HCI interface of master machine

The methods to realize various functions of the master machine software are introduced as follows:

2.1 Drawing of revolute speed waveform

To draw the speed waveform, this software uses the functions of CDC class in MFC library: MoveTo(POINT point) and LineTo(POINT point) to draw the revolute speed waveform manually. There is a subprogram, PlotLine (CPoint ptbgn, CPoint ptend, int nWidth, int style), designed for convenient drawing. Besides, it uses the TextOut function to display coordinates at the given point. When the master machine software gets the revolute speed data from slave machine, it will redraw the window and get all the revolute speed data from the buffer to redraw the waveform in the drawing area.

2.2 Dynamic variation of y-axis coordinates

The function is aimed at making it convenient to draw the waveform while the revolute speed changes in a large scale. It uses a sample algorithm to find an optimal ratio of pixel to revolute speed. The program flow chart is shown as Fig. 2.

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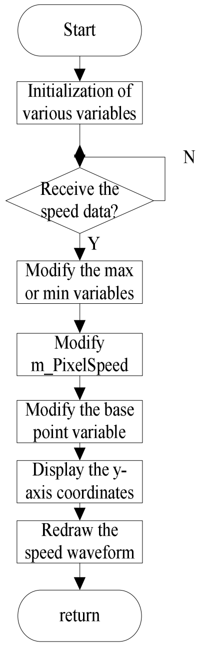

Figure 2. Dynamic variation of y-axis coordinates

2.3 Parameters setting

To set the parameters of each algorithm, the software has two setting dialogs, called Option Dialog and Test Items Dialog. The Option Dialog was designed to select the control algorithm, set the parameters of Conventional PID, initialize and RBF-PID algorithm as well as sample time. The Test Items Dialog aims to select the test item. The Option Dialog and Test Item Dialog are shown as Fig.3.

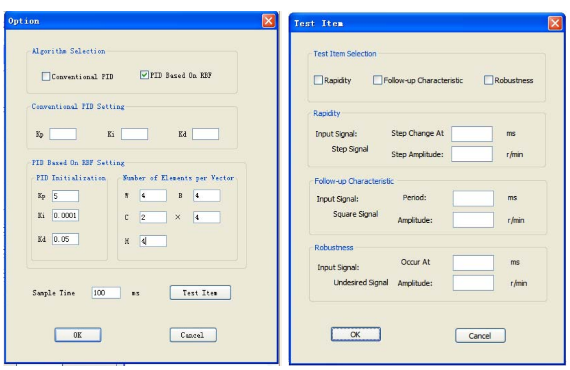

Figure 3. Option Dialog and Test Item Dialog

3. PROGRAMMING OF RBF-PID ALGORITHM

Single neuron PID control algorithm based on RBF neural network on-line identification is composed of RBF neural network and single neuron PID. Adopting the gradient-decline method of RBF neural network, it can adjust the PID parameters efficiently. Then the single neuron PID controller calculates the control output, which is send to controlled device. The schematic diagram of RBF-PID control is shown as Fig. 4 [7] while the flow chart of RBF-PID algorithm is shown as Fig. 5.

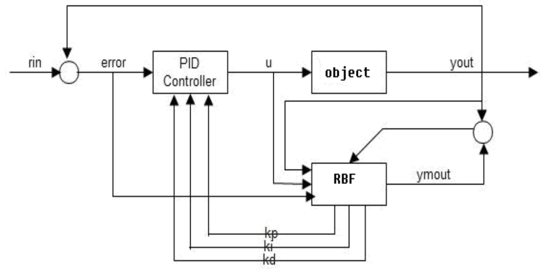

Figure 4. The schematic diagram of RBF-PID control

Besides, to accelerate the convergence of back propagation algorithm, an optimization algorithm for learning factor and momentum factor is presented to improve the RBF neural network. The Flow chart of optimization algorithm is shown as Fig. 6 (α is learning factor, η is momentum factor) [8].

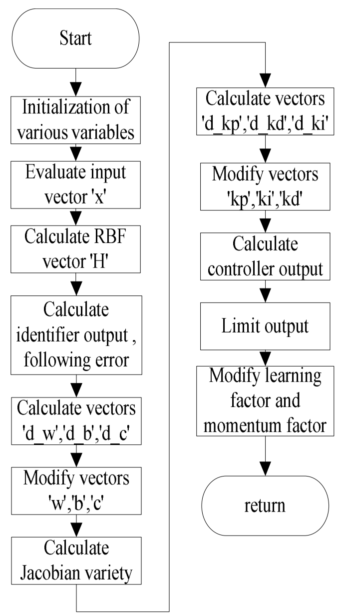

Figure 5. The flow chart of RBF-PID algorithm

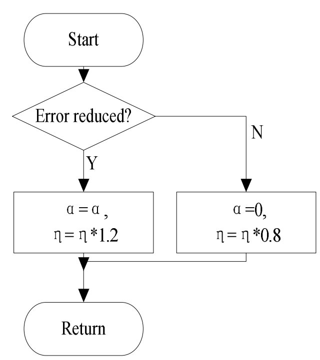

Figure 6. Optimization algorithm's program flow chart

4. DESIGN OF SLAVE MACHINE SOFTWARE

The slave machine takes 'TPDEM3 DEMO' development board based on dsPic30f single chip as the operation platform. Its functions mainly include: changing the PWM out ports to drive the BLDC running, measuring the rotation direction and revolute speed of BLDC in real time, and sending the state and revolute speed to master machine. The BLDC drive circuit is shown as Fig. 7.

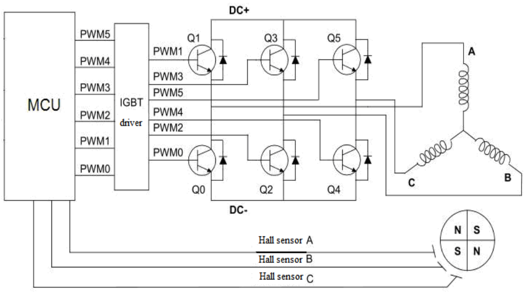

Figure 7. BLDC drive circuit

The concrete details to realize various functions of the slave machine are introduced as follows:

4.1 Measuring BLDC revolute speed in real time.

MCU sets a timer for sample time which sends an interrupt signal periodically. In the interrupt routine MCU could calculate the revolute speed with frequency the hall sensor change. This method actualizes simple and has highly stability.

4.2 Serial Communication

The data is transferred by serial communication between Master machine and slave machine. Once the simulation started, master machine sends control commands to slave machine every sample time which include start or stop command and rotation direction changing command, and then sends given revolute speed to slave machine. After getting the commands and given revolute speed, the slave machine will send BLDC state and the BLDC revolute speed back to master machine immediately.

5. EXPERIMENTS AND RESULTS BASED ON SIMULATION SYSTEM

All the experiments have been done in the condition that kp=0.9, ki=0.013, kd=1.7. And the sample time is 100ms. The results of experiments are shown as follows:

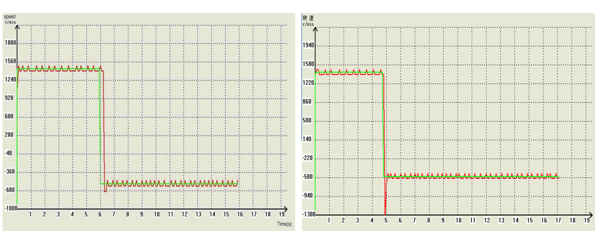

Figure 8. Rapidity test

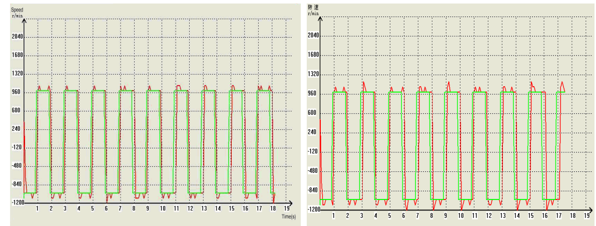

Figure 9. Follow-up Characteristic test

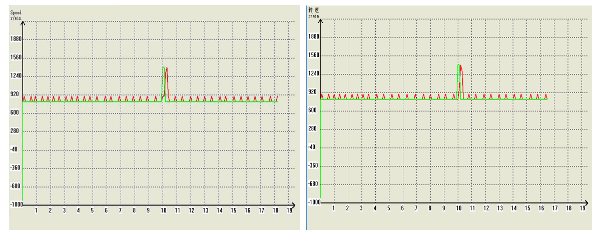

Figure 10. Robustness test

TABLE I. RAPIDITY TEST RESULTS

Algorithms	*Overshoot(Mp)*	*Adjustment time(ts)*
Conventional PID	37%	0.25s
RBF-PID	7%	0.45s

TABLE II. FOLLOW-UP CHARACTERISTIC TEST RESULTS

Algorithms	*Overshoot(Mp)*	*Adjustment time(ts)*
Conventional PID	10%	0.5s
RBF-PID	10%	0.2s

TABLE III. ROBUSTNESS TEST RESULTS

Algorithms	*Adjustment time(ts)*
Conventional PID	0.6s
RBF-PID	0.4s

The performance of these two controllers could be concluded from the results of experiments above. For one thing, RBF-PID controller has a better and quicker response in following either step signal or square-wave signal. For another thing, RBF-PID controller could return to normal state faster after interference occurred. Besides, RBF-PID controller performs better in the aspect of stability. To sum up, RBF-PID controller, compared with Conventional PID controller, has excellent control performance in BLDC revolute speed control.

6. CONCLUSIONS

With a convenient HCI interface, the system makes users easy to operate and come to conclusions from the results of experiments. First, two algorithms have been designed in the master machine software, so it is convenient to set any correlative parameters for users. Second, a waveform displayed in the operation interface makes it easy to observe the real-time revolute speed of BLDC motor. .In general, the system has a better performance in the aspects of testing and setting parameters of algorithms.

ACKNOWLEDGMENT

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