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PWM Waveform Generation Using Pulse-Type Hardware Neural Networks Circuit by Varying Synaptic Weights

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Abstract: This paper presents the pulse-type hardware neural networks circuit (P-HNNC) which could output the pulse width modulation (PWM) waveform of PWM servo motor for robots. Previously, we proposed the hardware neural networks which can output the PWM waveform. In this study, we used the synaptic model which could vary the synaptic weights by controlling voltage. The P-HNNC could output several pulse widths for PWM waveform by varying the synaptic weights. As a result, we clarified that P-HNNC could control the PWM servo motor from 0 to 180 degrees more smoothly and more simple circuits comparing with previous model.

1. Introduction

Programmed control by a microcomputer has been the dominant system among the robot control. However, these robot controlling system is not flexible autonomous control system such as a living body. Therefore, living body like flexible autonomous control system was desired.

In order to realize the flexible autonomous control system, some advanced studies of artificial neural networks have been paid attention for applying to the robot control. A lot of studies have reported both on mathematical neuron models and hardware neuron models. Using the mathematical neuron models in large scale neural networks is difficult to process in continuous time. In contrast, using the hardware neuron model is advantageous because even if a circuit scale becomes large, the nonlinear operation can perform at high speed and process in continuous time.

We are studying about implementation of hardware neural networks controlling system to robot system. Previously, we proposed the hardware neural networks which can output the PWM waveform [1].

This paper presents the pulse-type hardware neural networks circuit (P-HNNC) which could output the pulse width modulation (PWM) waveform of PWM servo motor for robots.

2. PWM Servo Motor

Figure 1 shows the example of pulse waveform to actuate the PWM servo motor. It is necessary to output the pulse waveform to control the servo motor.

Table 1 shows the pulse specifications of servo motor. The specifications were measured the control signal by oscilloscope.

It is shown that if the P-HNNC can output the waveform such as shown in Fig.1 satisfying the specifications of Table 1, the PWM servo motor can be control.

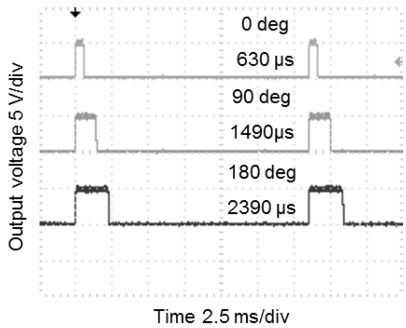

Figure 1. Pulse waveform to actuate the servo motor

Pulse period	16040 μs
peak-to-peak voltage	5.04 V
motion range	0 to 180 degree
increase of pulse width per degree	10 μs
minimum pulse width (0 degree)	600 μs
maximum pulse width (180 degree)	2400 μs

Table 1. Pulse specifications of servo motor (Hitec Multiplex Japan HSR-8498HB)

3. Pulse-Type Hardware Neural Networks Circuit

Figure 2 shows the schematic diagram of P-HNNC. P-HNNC consisted of a cell body model, synaptic model and axon model. In the figure, C indicates cell body model, A indicates axon model and S indicates synaptic model. This P-HNNC was constructed by the 12 cell body model,

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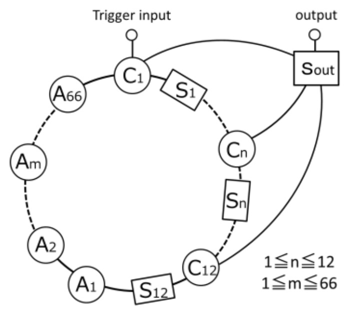

Figure 2. Schematic diagram of pulse-type hardware neural networks circuit

12 synaptic model and 66 axon model. In the case of inputting the external trigger pulse to C_1, the pulse propagated the ring neural networks with delay. One cell body model generates a pulse width of approximately 200 µs. Delay time of pulses was control by the synaptic weight. By changing the synaptic weights, the PWM waveform width could vary from 600 µs to 2400 µs.

Figure 3 shows the circuit diagram of cell body model. The

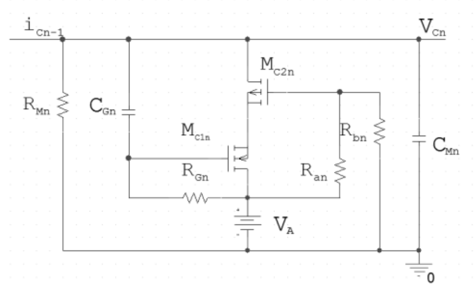

Figure 3. Circuit diagram of cell body model

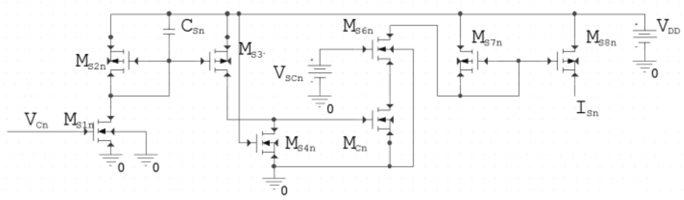

Figure 4. Circuit diagram of synaptic model

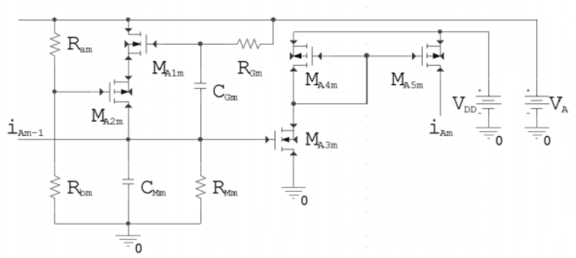

Figure 5. Circuit diagram of axon model

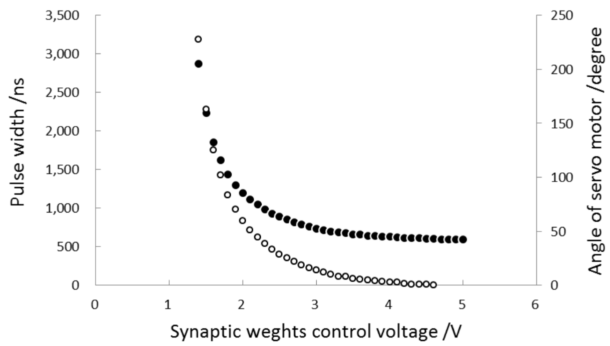

Figure 6. Synaptic weight control voltage vs. pulse width and angle of servo motor

cell body model had the negative resistance property which changed with time like a biological neuron, and enabled the generation of a continuous action potential V_{Cn} by a self-excited oscillation and a separately-excited oscillation.

Figure 4 shows the circuit diagram of synaptic model. The synaptic model can control a synaptic weights by varying the synaptic weights control voltage V_{SCn}.

Figure 5 shows the circuit diagram of axon model. The axon model could realize the pulse period (16040 µs) of PWM servo motor.

Figure 6 shows synaptic weight control voltage vs. pulse width and angle of servo motor. In the figure, solid circles indicates the pulse width and open circles indicates the estimation of the angle of the servo motor. This figure shows that our P-HNNC can change the pulse width of output waveform by changing the synaptic weights control voltage.

4. Conclusion

In this paper, we presented the pulse-type hardware neural networks circuit (P-HNNC) which could output the pulse width modulation (PWM) waveform of PWM servo motor for robots. As a result, we generated the PWM waveforms of different pulse widths by varying the synaptic weights.

In the future, we will integrate the pulse-type hardware neural networks circuit to the humanoid robot.

Reference

[1] K. Saito, M. kato, M. Takato, Y. Sekine and F. Uchikoba. “Pulse-type hardware neural networks circuit for PWM servo motor control”, Proc. of The Seventeenth International Symposium on Artificial Life and Robotics 2012, pp. 626-629, 2012