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A PULSED NEURAL NETWORK INCORPORATING SHORT TERM SYNAPTIC PLASTICITY FOR ENGINEERING APPLICATIONS

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Abstract. *The purpose of this paper is to propose a pulsed neuron model named Pulsed Neural Network incorporating Short-term Synaptic Plasticity (PNNSSP). PNNSSP extends PNN so as to change synaptic efficiency in accordance with pulse frequency. Results of computational experiments indicate PNNSSP requires less number of neurons and synapses which are necessary to build XOR function than PNN. Furthermore, experiments were conducted in which PNNSSP is used for a controller of a mobile robot as an engineering application of PNNSSP. As a result, it becomes clearer that the efficiency of the robot which uses PNNSSP for the controller is superior in comparison with PNN.*
Keywords: Pulsed neural network, Short-term synaptic plasticity, Mobile robot

1. **Introduction.** Recently, it has been considered that spatio-temporal activities of neurons play one of the important roles in functional definition of the neurons. In particular, temporal coding which is information processing based on pulse timing and frequency is especially significant. Research regarding the temporal coding has been done actively using Pulsed Neural Network (PNN). Long-term synaptic plasticity which is alteration of long-term transmission efficiency in actual neuron is modeled as Hebbian learning rule by Gerstner et al. [1]. In addition, it is known that the actual neuron adjusts short-term transmission efficiency which is called short-term synaptic plasticity [5]. Neuron models which incorporate a mechanism of short-term synaptic plasticity have already been proposed by Tsodyks et al. [5]. However, the purpose of Tsodyks' models is to simulate the behavior of the actual neuron. Therefore, equations of Tsodyks' models are complicated in comparison with a leaky integrate-and-fire neuron model which is used by Gerstner et al. It is thought that Tsodyks' models are unsuitable for engineering applications. The purpose of this paper is to propose a pulsed neuron model which is called Pulsed Neural Network incorporating Short-term Synaptic Plasticity (PNNSSP). PNNSSP extends PNN so as to change synaptic efficiency in accordance with pulse frequency. We demonstrate the advantages of PNNSSP by applying it to XOR function and a controller of a mobile robot.

2. **A model of PNN.** This study uses the leaky integrate-and-fire neuron model (Figure 1) which is the same model as used by Gerstner et al. [1] and Eurich et al. [2].

First of all, the behavior of the leaky integrate-and-fire neuron model is explained briefly as follows. A presynaptic neuron j and a postsynaptic neuron i are connected with