1-22

Four-Layer Feed-Forward Neural Network with Local Glia Connections

Chihiro IKUTA Yoko UWATE Yoshifumi NISHIO
(Tokushima University)

1. Introduction

A glia and a neuron are nervous cells. The neuron has been investigated about biological characteristics and applications. However, the glia had not been investigated very well, because this cell was considered to be a support cell of the neuron. Recently, some researchers discovered that the glia can transmit a signal by using an ion concentration [1]. The glia uses various ions which are a glutamate acid, an adenosine triphosphate, and so on. These ions are also used in a gap junction of the neuron. Thus, the glia closely relates to a human cerebration.

In this study, we propose a four-layer feed-forward neural network with local glia connections. This network is composed of four-layer of the neurons. We connect the glias to the neurons in two hidden-layers. The glias give the pulses to the connecting neurons according to outputs of the connecting neurons. The network receives the energy from the glia for escaping out from a local minimum. By the computer simulation, we confirm that the proposed network obtains a better performance than the standard network.

2. Proposed method

In this study, we propose the four-layer feed forward neural network with local glia connections which is shown in Fig. 1. We generally use the Back Propagation (BP) algorithm for a learning of the network. The BP algorithm is often used to the learning of the artificial neural network, however this algorithm falls into the local minimum [2]. For this problem, we connect the glia to the neuron in two hidden-layers. The glia receives and sums the connecting neuron outputs. If the summed value is over the glia excitation threshold, the glia generates the pulse. The pulse is input to a connecting neuron threshold. We consider that the glia gives the energy for escaping out from the local minimum.

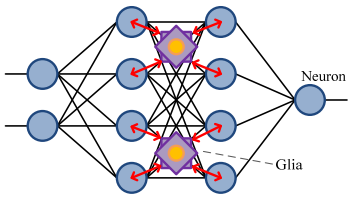

Figure 1: Proposed MLP.

The pulse generation rule of the glia is defined by Eq. (1).

$$\psi_i(t+1) = \begin{cases} 1, \ I_i = 0, \ (g_i(t) > \theta_g \cap I_i > \theta_t) \\ -1, \ I_i = 0, \ (g_i(t) < -\theta_g \cap I_i > \theta_t) \\ \gamma\psi_i(t), \ I_i = I_i + 1, \ else, \end{cases}, \quad (1)$$

where ψ is a glia output, g is a sum of outputs of the connecting neurons, γ is an attenuation parameter, θ_g is an excitation threshold of the glia, I is a time length of a non-excitation of the glia, and θ_t is a time length of a period of inactivity. The glia pulse is input to the neuron threshold. The neuron updating rule is described by Eq. (2).

$$y_i(t+1) = f\left(\sum_{j=1}^{n} w_{ij}(t)x_j(t) - \theta_i(t) + \alpha\psi_i(t)\right), \quad (2)$$

where α is a weight of glial effect and ψ is a pulse of glia.

3. Simulation

We use the Two-Spiral Problem for a learning task. The TSP is a famous task for the artificial neural network. In the TSP, coordinates of the spiral are input to the network. The network learns a classification of the spiral. In this simulation, the number of the learning datum are 198. The number of neurons are 2-10-10-1. The iterations are 500000. The number of trials are 100. We use three kinds of the networks for comparison of the performance.

(1) The standard network.

(2) The standard network with random noise.

(3) The proposed network.

The standard network does not have an external unit, thus it is often falls into local minimum. The MLP with random noise receives the uniformed random noise. The simulation result shows in Table 1.

From this table, the proposed network has a better performance than the standard network. The glia pulse improves the performance more than the uniformed random noise. Moreover, the random noise increases the maximum error than the standard network. From this result, the glia pulse has the influence different from the uniformed random noise.

Table 1: Learning performance.

	Average	Minimum	Maximum	Std. Dev.
(1)	0.01384	0.00001	0.08687	0.01959
(2)	0.01220	0.00000	0.09470	0.01772
(3)	0.00905	0.00001	0.07259	0.01234

4. Conclusions

In this study, we have proposed the four-layer feed forward neural network with local glia connections. The neurons in the hidden-layer are connected with the glias. The glia generates the pulse according to the connecting neuron output. After that the pulse is input to the connecting neuron threshold. The glia response gives the energy to the network. Thus, the glia pulse helps the network about escaping out from the local minimum. By the simulation, we confirmed that the glia response improves the learning performance of the network.

References

[1] P.G. Haydon, "Glia: Listening and Talking to the Synapse," *Nature Reviews Neuroscience*, vol. 2, pp. 844-847, 2001.

[2] D.E. Rumelhart, G.E. Hinton and R.J. Williams, "Learning Representations by Back-Propagating Errors," *Nature*, vol. 323-9, pp. 533-536, 1986.