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Improvement of Learning Performance by Recurrent Neural Network with Neurogenesis

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1. Introduction

In human brain, neuron had been considered to be lost with age until a few years ago. However, in a recent study, it was reported that the neurogenesis [1] occurs in the dentate gyrus in the hippocompus. The neurogenesis improves memory and thinking power of the human brain.

In this study, we introduce the neurogenesis into Recurrent Neural Network (RNN). Also, we apply the RNN with neurogenesis to pattern learning and investigate its performance.

2. RNN with Neurogenesis

First, we explain the RNN. The RNN is a neural network with self-feedback and asymmetric connections. Back Propagation Through Time (BPTT) is used as the RNN's learning method. The BPTT was introduced by Williams in 1989. The BPTT was based on an extension of the standard Back Propagation (BP) algorithm for a feed-forward neural network. The output function described as Eq. (1). Moreover, the internal state and sigmoid function which are used for output function are described as each Eq. (2) and (3).

$$x_i(t+1) = f\left(u_i(t+1)\right) \qquad (1)$$

$$u_i(t+1) = \sum_j w_{ij} x_j(t) \qquad (2)$$

$$f(u) = \frac{1}{1+e^{-u}} \qquad (3)$$

where x is the input or output, u is the internal state, w is the connection weight. The updating type of weight is described as Eq. (4).

$$\Delta w_{ij} = \eta \sum_{\tau=t_0}^{t-1} \delta_i(\tau+1) x_i(\tau) \qquad (4)$$

where η is the learning rate, τ is the time constant.

We propose the RNN with neurogenesis. Here, the neurogenesis is that some existing neurons are replaced with regeneration neurons in each learning of the RNN (see Fig. 1). Then, the connections of the existing neurons are regenerated by the neurogenesis. The position of the regeneration neurons are set randomly. And the regeneration connection weights are recasting. After the neurogenesis, the regenerated network learns pattern using BPTT.

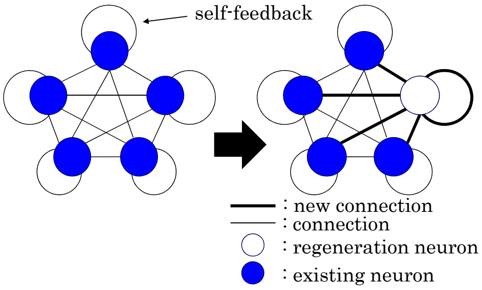

Figure 1: RNN with neurogenesis composition.

3. Simulation Results

We consider the RNN with 100 neurons. The RNN with neurogenesis leans 5000 times. An input pattern and a teaching pattern are shown in Fig. 2.

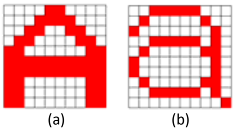

Figure 2: Learning pattern. (a) Input pattern. (b) Teaching pattern.

The existing neurons are randomly replaced by the regeneration neurons in each 1, 5 or 10 learning times till 50th learning time. The number of regeneration neurons changes by 10 steps in learning. After learning process, if difference value of corresponding position between the RNN with neurogenesis and the teaching pattern is less than 0.2, we consider as two patterns is agreement. We investigate the performance of the RNN with neurogenesis by counting the number of agreement every regeneration neuron positions. The simulation results are summarized in Tab. 1. This results are obtained from 10 average by changing the initial condition of RNN.

Table 1: Simulation Results. (a) The number of regeneration neurons. (b) The number of agreement.

Network type	(a)	(b)		
		timing		
		1	5	10
conventional	0	32.1	32.1	32.1
RNN with Neurogenesis	10	36.5	72	57
	20	32	90	72
	30	32	59.8	83
	40	32	36.3	90
	50	32	35.6	80.9
	60	32	32	55
	70	32	32.4	38.4
	80	32	32	36
	90	32	32	36
	100	32	32	34

From Tab. 1, the learning performance of the RNN with neurogenesis improves than the conventional RNN in a certain case. And maximum number of agreement is 90. This value is about three times as many as the conventional RNN's. Therefore, it is confirmed that the learning performance of the RNN with neurogenesis depends on frequency of the neurogenesis and the number of regeneration neurons.

4. Conclusions

In this study, we proposed the RNN with neurogenesis The learning performance of the RNN with neurogenesis improves than the conventional RNN in the certain case.

References

[1] Suzanna Becker, J.Martin Wojtowicz,"A model of hippocampal neurogenesis in memory and mood disorders", *TrendsCogn, Sci.* 11(2), 70-76. 2007.