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Back Propagation with Chaotic Change of Thresholds for Two-Spiral Problem

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1. Introduction

Back Propagation (BP) was introduced by Rumelhart in 1986 [1]. BP is used for learning of Multi-Layer Perceptron (MLP) and the error is propagating backward in the network. MLP after BP learning is known to be possible to perform pattern classification tasks. However, network's output often falls into local minimum, because BP uses the steepest descent method. We need to adopt a method to release the solution from the local minimum.

In this study, we propose a method using independent chaotic oscillation for the neuron units' thresholds. The conventional MLP's thresholds are decided by BP learning. In our method, the thresholds are updated by BP and also affected by independent chaotic oscillations. We apply the proposed method to the Two-Spiral Problem and confirm the efficiency by computer simulations.

2. Updating Rule of Neuron

We consider the MLP composed of four layers (connected 2-20-40-1, Fig. 1). The updating rule of the network is given by Eq. (1). The sigmoidal function (2) is used for the output function.

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

$$f(a) = \frac{1}{1+e^{-a}} \quad (2)$$

where x: input or output, w: weight parameter, θ: threshold, ζ: chaotic oscillation, α: amplitude of chaos. Square error (3) is used for error evaluation in BP.

$$E = \frac{1}{2}\sum_{i=1}^{n}(t_i - O_i)^2 \quad (3)$$

t: target value, O: output value. We use the tent map (4) to produce chaotic oscillation and the values are exploited to fluctuate the threshold value of each unit.

$$\zeta_i(t+1) = \begin{cases} 2\zeta_i(t) & (0 < \zeta_i(t) \leq 1/2) \\ 2 - 2\zeta_i(t) & (1/2 < \zeta_i(t) < 1) \end{cases} \quad (4)$$

We chose different initial values for ζ_i, so different chaotic sequences affect every neurons.

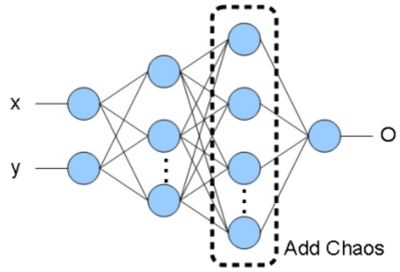

Figure 1: Network composition.

3. Simulation Results

We apply the proposed method to the two-spiral problem. This problem is famous for its difficulty [2]. We use 98 data of two spirals and they are shown in Fig. 2. The maximum learning time of MLP is 50000 and we checked the averaged error of the output in every 50 learnings.

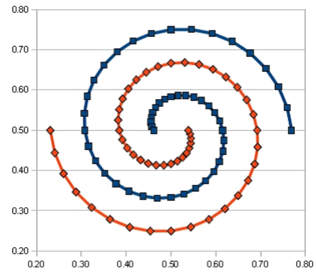

Figure 2: Data of two-spiral problem.

Figure 3 shows the learning curves for the conventional BP learning and the proposed method with chaotic change of the thresholds. We can see that the conventional BP learning is trapped into a local minimum and that the performance cannot be improved. However, the proposed method makes the network to escape out from the local minimum and obtain better performance.

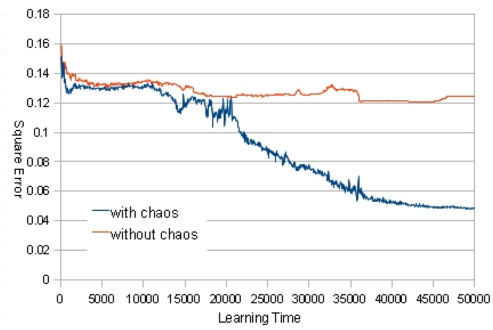

Figure 3: Simulation result.

4. Conclusions

In this study, we have proposed a method to adopt chaotic oscillations to neuron units' thresholds. Computer simulation results of two-spiral problem showed that the proposed method had an ability for the network to escape out from the local minimum and obtained better results. We consider that the drop of the threshold might be related with the existence of the Glia cells. The detailed investigation of the effect is our future work.

References

[1] D.E. Rumelhart, G.E. Hinton, and R.J. Williams, "Learning representations by back-propagating errors," Nature, vol.323-9, pp.533-536, 1986.

[2] J.R. Alvarez-Sanchez, "Injecting knowledge into the solution of the two-spiral problem," Neural Computing & Applications, vol.8, pp.265-272, 1999.