1-23

Feed-forward Neural Networks with Temporal Change in Gradient of Sigmoid Functions

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1. Introduction

Neural network is constituted by some element that is called neuron. This network is based on animal brain. With similarity brain, it is appropriate in recognize written characters and recognize voice. Features of neural network are parallel processing and learning. From these features, neural network is appropriate in recognize brain signal, too. Because the learning of neural network can learn brain signal that has differences with each person and condition. However, the recognition brain signal rate is 86 percent in other research. Recognition rate is important for making widgets. For decreasing this rate, the challenge is making similar output signal to perfect signal. Although, the error can not become zero, because of learning method. So our task is reducing error close to zero.

In this study, we focus on the learning method of Feed-forward neural network. Back propagation is the learning method of Feed-forward neural network. We change sigmoid functions and improve back propagation.

2. Proposed method

In this study, we change gradient of sigmoid functions at iteration. Sigmoid functions is used in converting input signal to output signal at learning of neural network. We decrease the parameter "k" that is coefficient added into natural logarithm's multiplier.

$$f(x) = \frac{1}{1 + exp(-kx)} \tag{1}$$

Figure 1 shows sigmoid functions with changing "k" and Fig. 2 shows differential form of sigmoid functions.

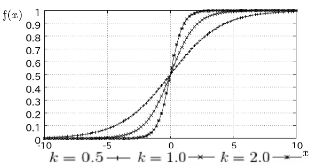

Figure 1: Sigmoid functions with "k".

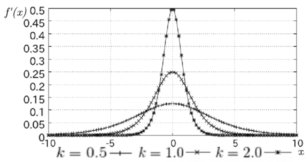

Figure 2: Differencial form of sigmoid functions.

We decrease "k" by 0.3 at starting proposed method and decrease "k" by 0.001 at iteration.

3. Simulation results

We divide Iris plants into 3 types. There are total of 150 data entries. The data records 4 attributes and 3 classifications. The 4 attributes are sepal length, sepal width, petal length and petal width. The 3 types of iris flower are Iris Setosa, Iris Versicolor and Iris Virginica. We define parameters as learning iteration = 1000 and the number of hidden layer's neurons = 4.

First, we search the learning rate (a) that has the smallest error. Table 1 shows the error with changing learning rate from 0.1 to 1.0.

Table 1: The error with changing a

a	0.1	0.2	0.3	0.4	0.5
ave	0.02896	0.02438	0.02974	0.02261	0.02144
a	0.6	0.7	0.8	0.9	1.0
ave	0.02144	0.02079	0.02137	0.02112	0.02144

We define as the learning rate = 0.7, because it has the smallest error. We use this learning rate in the next simulation. The simulation result of conventional method is shown in Fig 3.

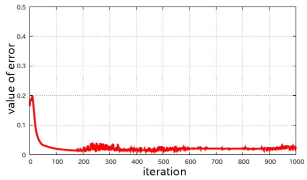

Figure 3: Conventional learning.

Next, we simulate the proposed method and change timing of starting proposed method.

Table 2 shows the error of proposed method. We show only starting proposed method since 300 iteration.

Table 2: The error of proposed method

a	0.1	0.2	0.3	0.4	0.5
ave	0.10816	0.09496	0.08314	0.01304	0.01106
a	0.6	0.7	0.8	0.9	1.0
ave	0.01465	0.01575	0.01514	0.01659	0.01690

In this simulation, we obtain very small error. This method is effective to improve back propagation. The simulation result of our proposed method is shown in Fig 4.

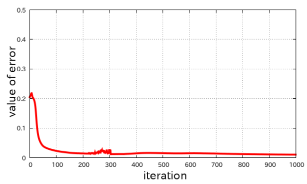

Figure 4: Proposed learning.

From Fig 4, the wave is lost since starting decreasing "k". This phenomenon means stabler learning than conventional method.

4. Conclusions

Our learning method is changing gradient of sigmoid functions by decreasing "k" at iteration for back propagation in feed-forward neural network. In these simulations, we obtain smaller error than the conventional method. However, if the "k" is small and starting decreasing time is early, our method makes error very large. So, this method requires attention to set parameters.

In the future work, we resolution that why the error becomes small with our method.