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동적 역치 조정을 이용한 퍼지 단층 퍼셉트론

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Fuzzy Single Layer Perceptron using Dynamic Adjustment of Threshold

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요 약

최근에 퍼지 이론을 인공 신경망에 접목하여 개선된 성능을 보이려는 경향이 많다. Goh는 퍼지단층 퍼셉트론 알고리즘과 일반적인 델타 규칙(Generalized delta rule)에 기반한 개선된 퍼지 퍼셉트론을 제안하여 Exclusive-OR(XOR) 문제 등을 해결하였다. 그러나 이 방법은 계산량의 증가와 복잡한 영상인식에 적용하기에는 어려움이 있다. 논문에서는 동적 역치조정에 의한 개선된 퍼지 단층 퍼셉트론을 제안한다. 제안된 방법은 패턴인식의 밴치마크로 사용되는 XOR 문제에 적용된다. 또한 영상 응용영역으로서 디지털 영상의 인식에 적용한다. 실험결과에서 항상 수렴하지는 않지만 그러나 제안된 모델은 학습시간의 개선과 높은 수렴율을 보였다.

Abstract

Recently, there are a lot of endeavor to implement a fuzzy theory to artificial neural network. Goh proposed the fuzzy single layer perceptron algorithm and advanced fuzzy perceptron based on the generalized delta rule to solve the XOR problem and the classical problem. However, it causes an increased amount of computation and some difficulties in application of the complicated image recognition. In this paper, we propose an enhanced fuzzy single layer perceptron using the dynamic adjustment of threshold. This method is applied to the XOR problem, which used as the benchmark in the field of pattern recognition. The method is also applied to the recognition of digital image for image application. In a result of experiment, it does not always guarantee the convergence. However, the network show improved the learning time and has the high convergence rate.

▸ Keyword : Fuzzy single perceptron, Learning time , Convergence rate

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I. Introduction

In the conventional single layer perceptron, it is inappropriate to use when a decision boundary for classifying input pattern does not composed of hyper plane. Moreover, the conventional single layer perceptron, due to its use of unit function, was highly sensitive to change in the weights, difficult to implement and could not learn from past data[1]. Therefore, it could not find a solution of the exclusive OR problem, the benchmark.

There are a lot of endeavor to implement a fuzzy theory to artificial neural network[2][7,[8]. Goh et al.[3] proposed the fuzzy single layer perceptron algorithm, and advanced fuzzy perceptron based on the generalized delta rule to solve the XOR problem, and the classical problem[3]. This algorithm guarantees some degree of stability and convergence in application using fuzzy data, however, it causes an increased amount of computation and some difficulties in application of the complicated image recognition. However, the enhanced fuzzy perceptron has shortcomings such as possibility of falling in local minima and slow learning time[4].

In this paper, we propose an enhanced fuzzy single layer perceptron using the dynamic adjustment of threshold. We construct, and train, a novel single layer perceptron using Auto-Tuning Method of Threshold. We will show that such properties can guarantee to find solutions for the problems such as exclusive OR, and digit image recognition on which conventional fuzzy single layer perceptron can not do.

II. A Fuzzy Single Layer Perceptron

The learning algorithm for our single layer perceptron will be proposed. Before we discuss an enhanced fuzzy single layer perceptron, we introduce the proposed learning architecture. (Fig.1) shows the architecture of the new learning algorithm.

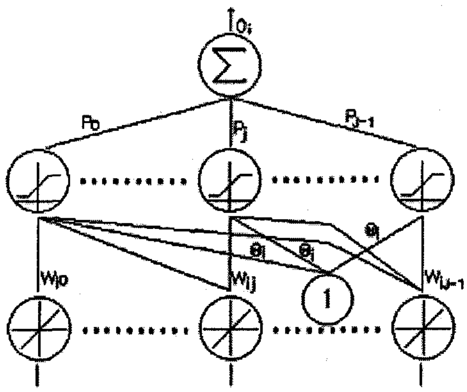

Fig. 1 A single layer perceptron model

2.1 A Fuzzy Single Layer Learning Algorithm

A proposed learning algorithm can be simplified and divided into four steps. For each input, repeat step 1, step 2, step 3, and step 4 until error is minimized.

[Step 1]: Initialize weight and bias term.

- Define, $W_{ij}(1 \leq i \leq I)$ to be the weight from input j to output i at time t and Θ_i to be the bias term in the output soma. Set $W_{ij}(0)$ to small random values, thus initializing all the weights and bias term.

[Step 2]: Rearrange A_i according to the ascending order of membership degree m_j and add an item m_0 at the beginning of this sequence.

$$0.0 = m_0 \le m_1 \le \Lambda \le m_j \le m_J \le 1.0$$

Compute the consecutive difference between the items of the sequence.

$$P_k = m_j - m_{j-1}, \ where\ k = 0, \cdots, n,$$

[Step 3]: Calculate a soma (O_i)'s actual output.

$$O_i = \sum_{k=0}^{J-1} P_k \times f\left(\sum_{j=k}^{J-1} W_{ij} + \theta_i\right)$$

where $f\left(\sum_{j=k}^{J-1} W_{ij} + \theta_i\right)$ is a sigmoid function and $i = 1, \Lambda, I$

[Step 4]: Applying the modified delta rule. And we derive the incremental changes for weight and bias term.

$$\Delta W_{ij}(t+1) = \eta_i \times E_i \times \sum_{k=0}^{j} P_k \times f\left(\sum_{j=k}^{J-1} W_{ij} + \theta_i\right) + \alpha_i \times \Delta W_{ij}(t)$$

$$W_{ij}(t+1) = W_{ij}(t+1) + \Delta W_{ij}(t+1)$$

$$\Delta\theta_i(t+1) = \eta_i \times E_i \times f(\theta_{ij} + \alpha_i \times \Delta\theta_i(t))$$

$$\theta_{ij}(t+1) = \theta_{ij}(t) + \Delta\theta_{ij}(t+1)$$

where η_i is learning rate α_i is momentum

2.2 Automatic Tuning of Threshold using Fuzzy Intersection Operator

The fuzzy intersection operator has the property that the output value is not greater than the minimum value in all input values, and the Yager's intersection operator[5] is described in Eq. (1).

$$\mu_{X_1} \cap \mu_{X_2} = 1 - Min\left[1, \left((1-\mu_{X_1})^p + (1-\mu_{X_2})^p \right)^{1/p}\right] \quad \cdots\cdots (1)$$

Yager's intersection operator converges to the min-operator for $p \to \infty$. Yager's intersection operator is the special feature that the aggregated value is not more than the smallest value among all inputs.

Controlling the operator and the parameter value needed by transfer function of hierarchical neural network using such an operator, the pessimistic and optimistic propensity appearing in information merging can be decided automatically.

In the problem of adjusting threshold of transfer function, the learning is performed with automatically decreasing threshold from the maximum value "1" by fuzzy operator, i.e. intersection operator of Yager satisfying the each pattern simultaneously.

Threshold is set by the compensative operator, which uses the calculated maximum and minimum value. On the occasion of this method, the network is prevented from rapidly decreasing and becomes modified with satisfying automatically the pessimistic and optimistic degree.

In the Conventional method, because each pattern is learned with fixed threshold, it may result in an inappropriate classifying by decision plain. Therefore, the proposed structure can classify the decision plain by controlling the threshold. That is, the problem of fixed threshold was improved by dynamically adjusting by the Yager's generalized intersection operator. Where $p = 2$ was used on the basis of experiment.

(Fig.2) shows the proposed threshold dynamic adjustment method.

Case of Comparison $(Error^{old}\ \&\ Error^{present})$

{

"π" : { $value^{max} = Threshold^{old}$

$value^{min} = Threshold$ }

"=" : Skip

"ϕ" : { $value^{min} = Threshold^{old}$

$value^{max} = Threshold$ }

}

$Error^{old} = Error^{present}$

$Threshold^{old} = value^{max}$

$Threshold = 1 -$

$Min[1, ((1 - value^{max})^p + (1 - value^{min})^p)^{1/p}]$

Fig. 2. Threshold dynamic adjustment method

We simulated the proposed method on IBM PC/586 with VC++ language. In order to evaluate the proposed algorithm, we applied it to the exclusive OR using benchmark in neural network and recognition problems, a kind of image recognition. In the proposed algorithm, the error criterion was set to 0.0.

3.1 Exclusive OR

Here, we set up initial learning rate and initial momentum as 0.5 and 0.75, respectively. Also we set up the range of weight [0,1].In general, the range of weights were [-0.5,0.5] or [-1,1].shown in ⟨Table 1⟩. The proposed method showed higher performance than fuzzy perceptron in convergence epochs and convergence rates of the three tasks.

Table 1. Convergence rate in initial weight range

Epoch No	Conventional Fuzzy Single Layer Perceptron	Proposed Algorithm	Initial Weight Range
XOR	8	3	[0.0, 1.0]
	15	8	[0.0, 5.0]

(Fig. 3) is showing the graph of the change of threshold by the number of epoch. As shown in (Fig.3), The threshold value was decreased automatically using fuzzy intersection operator.

3.2 ID code recognition

For performance evaluation, we compared the proposed algorithm with conventional fuzzy single layer perceptron using 10 ID codes extracted from student ID cards. The region of ID code was extracted by two procedures.

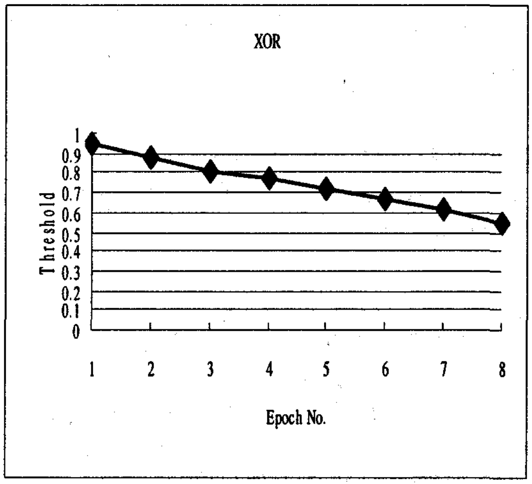

Fig. 3. Threshold variation in each step

First the region containing the ID numbers was extracted from the ID card image. Then the individual numbers were extracted from that field. The individual ID code was extracted as follows: The presented scheme sets up an average brightness as a threshold, based on the brightest pixel and the least bright one for the source image of the ID card.

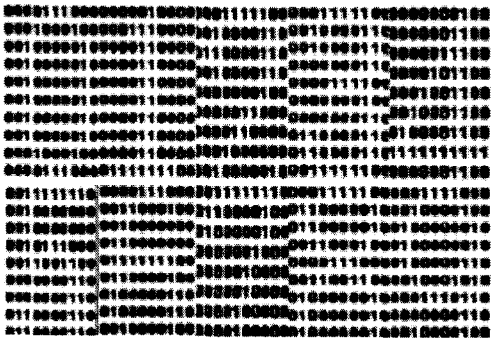

Fig. 4. ID code training data by ID card image

After converting to a binary image, a horizontal histogram was applied and the ID code was extracted from the image. Then the noise was removed from the ID code region using mode smoothing with a 3 X3 mask. After removing noise from the ID-code region, the individual ID code was extracted using a vertical histogram [6].

The input units were composed of 10× 10 array for image patterns. In simulation, the fuzzy perceptron was not converged, but the proposed method was converged on 65 steps at image patterns. 〈Table 2〉 is shown the summary of results in training epochs between two algorithms.

Table 2. The comparison of epoch number

Image Pattern	Epoch Number
Conventional fuzzy single layer perceptron	0(not converge)
Proposed algorithm	63(converge)

Ⅳ. Conclusions

We have proposed an enhanced fuzzy single layer perceptron using auto-tuning method of threshold, which has greater stability and functional varieties compared with the conventional fuzzy single layer perceptron.

The proposed network is able to extend the arbitrary layers and has high convergence in case of two layers or more. Though, we considered only the case of single layer, the networks has the capability of high speed during the learning process and rapid processing on huge images patterns.

The proposed algorithm shows the possibility of the application to the image recognition besides benchmark test in neural network by single layer structure.

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