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Application of Max-Plus Based Neural Networks to Medical Informatics

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Abstract. *In the last decades, various computational intelligence techniques have been used to help effective medical decision. In this paper, morphological neural networks are applied to intelligent diagnosis of heart disease. In the case of morphological neural networks, the advantages are mainly correspond to high speed/parallel processing, analyzing information in terms of ordered structure, and treating only discrete information with no quantization error. To optimize the connection weights of morphological neural networks, the memetic algorithm is considered rather than the gradient-based learning methods because of its poor convergence properties. We use heart disease data set available on the Machine Learning Repository site at the University of California at Irvine.*

Keywords: *Heart disease diagnosis, Morphological neural networks, Machine learning*

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I. Introduction

In the last decades, computational intelligence-based intelligent diagnosis of disease becomes more popular because of powerful performance of computational intelligence algorithms. Variety of researches related to computational intelligence-based intelligent diagnosis of disease has been considered [1]-[3].

In this paper, morphological neural networks (MNNs) [4][5] are applied to intelligent diagnosis of heart disease. In the case of morphological neural networks, the advantages are mainly correspond to high speed/parallel processing, analyzing information in terms of ordered structure, and treating only discrete information with no quantization error. To optimize the connection weights of morphological neural networks, the memetic algorithm [6] is considered rather than the gradient-based learning methods because of its poor convergence properties. We use heart disease data set available on the Machine Learning Repository site at the University of California at Irvine to show the applicability of the propose method.

II. Morphological Neural Networks [4]

This paper is a new application version of the morphological neural networks (MNNs), proposed by the author in [4], to automatic diagnosis of heart disease. Therefore, the same version of morphological neural networks and its optimization method in [4] are used in this paper. For this reason, all of this section directly refers to [4]. For more details about the morphological neural networks, please refer to [4].

Morphological neural networks are constructed based on morphological operators [4][5] which are defined as, ‘max{ a, b}’ and ‘a+b’, instead of standard addition and multiplication in ordinal algebra, respectively. This paper considers the morphological neural networks with three layers (input, middle, and output layers), as shown in Fig. 1, where the input, middle, and output layer vectors with N_I , N_m , and N_O dimensions, respectively.

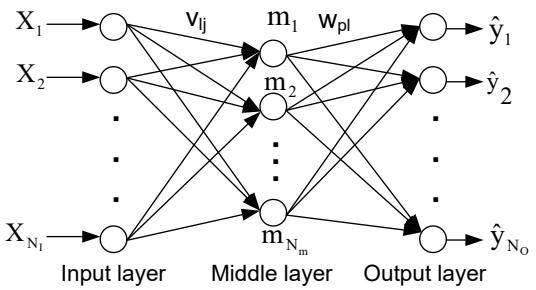

Fig. 1. Structure of the morphological neural networks

According to the definition of morphological operations, the middle layer vector can be calculated as

$$m_l = \max_{j=1}^{N_I} \{v_{lj} + x_j\}, \quad l = 1,2,...,N_m \tag{1}$$

and the output layer vector is calculated as

$$\hat{y}_p = \max_{l=1}^{N_m} \{w_{pl} + m_l\}, \quad p = 1,2,...,N_o \tag{2}$$

To optimize the connection weights of the morphological neural networks, the memetic algorithm [6] was also considered rather than the gradient-based learning methods because of its poor convergence properties. As proved in [6], the memetic algorithms are more effective than the optimization scenario of other genetic algorithms [7]. Therefore, the optimization scenario in [6] will be considered in this approach.

III. Experimental Results

In this section, we consider heart disease intelligent diagnosis problem. Heart disease data set is available on the Machine Learning Repository site at the University of California at Irvine. The heart disease data set has 303 instances and 6 samples have missing attributes. The data set has 76 attributes, but all the researches only use 14 of them (13 input attributes and 1 output attribute (heart disease: four types)) as shown in Table 1.

Table 1. Attribute information of Heart disease data set

Attribute name	Data type	Description
age	Continuous	Age in years
sex	Male/female	Sex of subject
CP	Four types	Chest pain
trestbps	Continuous	Resting blood pressure
chol	Continuous	Serum cholesterol
fbs	< or >120mg/dl	Fast blood sugar
restecg	Five values	Resting electrocardiographic result
thalach	Continuous	Maximum heart rate achieved
exang	Yes/no	Exercise induced angina
oldpeak	Continuous	ST depression induced by exercise relative to rest
slope	Up/flat/down	Slope of peak exercise ST segment
ca	0-3	Number of major vessels colored by fluoroscopy
thal	Normal/fixed/reversible	Defect type
num	Four types	Heart disease

Table 2. Average prediction rates over 20 times independent simulations

	Training data set	Testing data set
Average prediction rate (%)	81.1	80.3

The considered parameter values for the experiments are described as follows: number of input node=15, number of hidden node=20, number of output node=4, range of connection weights=[-0.5, 0.5], and the data sets were normalized in [0, 1]. The used parameter values for the optimization are the same as [6] except the population size (1000) and maximum generation number (2000).

To apply the morphological neural networks to classification problems, the output (class) should be discretized as binary. For example, if we assume that there are 4 classes (four types) in the data sets, the number of output crisp set should be 4. If the type belongs to the 2nd-class, the Boolean output can be discretized as "0 1 0 0". In this diagnosis problem, the winner-take-all method was used to decide the type.

We selected 70% of the data from the classes evenly as random for the training and the rest 30% was used for testing. 20 times independent simulations have been performed with different training and testing data set selected from the classes evenly. The average classification rates over 20 time independent simulations are

described in Table 2. As is shown in the results, the optimized morphological neural networks can be applied to intelligent diagnosis of heart disease with reasonable prediction rate.

IV. Conclusions

In this paper, morphological neural networks were applied to intelligent diagnosis of heart disease. In the case of morphological neural networks, the advantages are mainly correspond to high speed/parallel processing, analyzing information in terms of ordered structure, and treating only discrete information with no quantization error. To optimize the connection weights of morphological neural networks, the memetic algorithm was considered rather than the gradient-based learning methods because of its poor convergence properties. The heart disease data set available on the Machine Learning Repository site at the University of California at Irvine was considered to show the effectiveness of the proposed method. As is shown in the results, the optimized morphological neural networks can diagnose the heart disease with reasonable prediction rate.

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