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Prediction of coronary artery plaque type based on Neural Network

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Abstract: With the aging of Chinese society, coronary heart disease has become one of the most common diseases of heart disease in China. The main cause of coronary heart disease is the formation of atherosclerotic plaque. If a patient develops atherosclerotic plaque and is not treated promptly and effectively, it can eventually lead to an acute myocardial infarction. Therefore, using statistical methods to accurately predict plaque types based on clinical data for clinical treatment can significantly reduce the risk of myocardial infarction.

This paper is divided into three parts. The first part is the introduction, which mainly introduces the research background, significance and status of medical coronary plaque. The second part mainly introduces data description and analysis methods; The third part is the experimental steps and results analysis, mainly based on LVQ neural network to predict plaque types based on different risk factor indexes of coronary artery plaque formation, and introduces the knowledge principle of LVQ neural network, the practical modeling operation of this problem, and the use of MATLAB to predict plaque types.

At the end of the paper, the results of the practical modeling of the problem were summarized, and Suggestions on how to prevent the formation of coronary artery plaque for clinical treatment were put forward.

Keywords: coronary heart disease; Coronary plaque; The neural network

1、Introduction

This chapter is the introduction, which mainly introduces the background, significance and current research status of medical coronary plaque. The significance of studying coronary plaque and the methods and models involved in problem analysis are described in detail.

1.1 Research background

With the aging of Chinese society, coronary heart disease has become one of the most common diseases of heart disease in China. The main cause of coronary heart disease is the formation of atherosclerotic plaque. If a patient develops atherosclerotic plaque and is not treated promptly and effectively, it can eventually lead to an acute myocardial infarction. Therefore, the risk of myocardial infarction can be significantly reduced by studying the risk factors of coronary plaque formation and predicting the types of plaque in clinical treatment. Learning vector quantization neural network is an input forward neural network, which is a kind of neural network for training competitive layer with supervised learning method, and its algorithm is evolved from

Kohonen competitive algorithm. LVQ neural network has been widely used in the fields of prediction, classification, pattern recognition and model optimization. LVQ neural network can be used to predict plaque types based on the risk factors of different coronary artery plaque formation.

1.2 Research status

The formation of atherosclerotic plaque is the most important cause of coronary heart disease. If a patient develops atherosclerotic plaque and is not treated promptly and effectively, it can easily lead to acute myocardial infarction. Therefore, the risk of myocardial infarction can be significantly reduced by studying the risk factors of coronary plaque formation and predicting the types of plaque in clinical treatment. In recent years, scientists have analyzed and predicted the risk factors of coronary plaque formation.

(1) The impact of genetic risk and adherence to a healthy lifestyle on coronary artery disease.

In December 2016, the world's top medical journal NEJM published an analysis of the impact of lifestyle and genetic risk on coronary artery disease. Researchers will DNA sequence polymorphism of many genes scoring method, is applied to the research, respectively, with three more prospective cohort study of quantitative genetic risk for coronary artery disease, the researchers used includes four factors: smoking, obesity, physical activity frequency and the dietary habits of the score model to analysis the researchers healthy lifestyle from sex. Finally, it concluded that people with a good lifestyle had a significantly lower risk of coronary events than those with a bad lifestyle, regardless of the level of genetic risk.

(2) The influence of Evolocumab on the progression of coronary artery disease.

In a study published in JAMA, one of the world's leading medical journals, Stephen j. icholls, PhD, and his team at the university of adelade's southern Australian institute of health and medical research, examined the effect of the PCSK9 inhibitor Evolocumab on the progression of coronary atherosclerosis in statin patients. The study found that patients with coronary heart disease treated with statins significantly reduced their risk of developing coronary heart disease compared with placebo.

(3) Relationship between blood homocysteine (Hcy) and serum uric acid level and the nature of coronary plaque.

In 2018, kong chaomin et al. published a paper in the Chinese journal of circulation. 150 cases of suspected coronary heart disease patients were treated in tianjin chest hospital. According to the angiography results, the data were divided into control group (no coronary plaque), stable plaque group (calcification dominated by plaque) and high-risk plaque group (50 cases each). According to the Logistic regression of ordered multiple classification, Hcy was significantly correlated with the stability of coronary plaque.

(4) Pattern recognition and optimization of LVQ neural network

LVQ neural network combines the competitive learning idea with the characteristics of supervised learning algorithm, and USES the teacher signal to regulate the distribution of input samples, so as to overcome the shortcoming of the self-organized network that adopts unsupervised learning algorithm and lacks predictive classification information. In 2017, an LVQ neural network was used to identify the 13 chemical constituents in

three different wines from the same region of Italy. The researchers expected to achieve the purpose of actively classifying wines through LVQ neural network. Therefore, LVQ neural network pattern recognition and optimization can be applied to automatic diagnosis and classification of medical diseases.

1.3 Research program

LVQ neural network is widely used in the field of pattern recognition and optimization. Based on Matlab, I will use LVQ neural network to predict the plaque types based on the risk factor indexes of different coronary artery plaque formation.

In this paper, LVQ neural network was mainly used to predict the plaque types based on the risk factor indexes of different coronary artery plaque formation, and the knowledge principle of LVQ neural network and the practical modeling operation of this problem were introduced, as well as the prediction results of plaque types using MATLAB.

2. Data description and analysis methods

2.1 Description of plaque type prediction problems

In order to predict the types of different coronary plaque, a random sample of 280 people was examined by 64-slice CT, and the presence and types of coronary plaque were recorded, and relevant influencing factors were investigated. Twelve variables (age, sex, BMI, family history of coronary heart disease, hypertension, diabetes, smoking history, total cholesterol, high-density lipoprotein, triglyceride, blood glucose, creatinine) were included in the database, and these characteristics were closely related to the type of plaque. Therefore, it is necessary to establish a definite model to predict patch types according to each quantitative feature in the database.

2.2 overview of LVQ neural network

Learning Vector Quantization (LVQ) is a forward supervised neural network which is evolved from a competition algorithm by Kohonen, a Finnish scholar. LVQ neural network has been widely used in the field of pattern recognition and optimization.

(1) Structure of LVQ neural network

LVQ neural network is mainly composed of three layers of neurons, including input layer, competition layer and linear output layer. Most neural networks are composed of input layer, hidden layer and linear output layer. The connection mode between LVQ neural network contactor layer and linear output layer is local connection, while the connection mode between input layer and contactor layer is full link.

(2) Learning algorithm of LVQ neural network.

LVQ neural network algorithm is an extension ofSOM algorithm. The basic theory comes from SOM algorithm, and it can also be interpreted as a learning algorithm that trains the competitive layer with teachers. LVQ neural network algorithm includes LVQ1 algorithm and LVQ2 algorithm. LVQ1 algorithm is used in this problem analysis. The basic idea of this algorithm is to calculate the distance of a competing layer neuron so that it is closest to the input vector, so that the linear output layer neuron can be found according to this

competing layer neuron. If the class of neurons in the linear output layer and the class of neurons in the input vector are identical, then the weights of the neurons in the competing layer should be moved in the direction of the input vector. If the class of neurons in the linear output layer and the class of neurons in the input vector are inconsistent, then the weights of the neurons in the corresponding competing layer should be shifted to the opposite direction of the input vector. The basic steps of LVQ1 algorithm are as follows:

Step 1: Initialize the weights between input layer and competitionw_{ij} vector andη（$\eta > 0$）.

Step 2: Feed the input vector $x =$ （x_1， x_2， …， x_R）^{T} into the input layer, and calculate the distance between the competing layer neuron and the input vector:

$$d_i = \sqrt{\sum_{j=1}^{R} （x_j - w_{ij} ）^2} \quad \mathrm{i} = 1,2, \ldots, S^1$$

Where, w_{ij} is the weight between neuron j of input layer and neuron i of competition layer.

Step 3: Find and select the competing layer neuron with the smallest distance from the input vector. If the distance from d_i is the smallest, the class label of the corresponding connected linear output layer neuron should be noted as C_i

Step 4: Mark the class label corresponding to the input vector as C_x. If $C_i = C_x$, adjust the weight value by the following method:

$$w_{ij\_new} = w_{ij\_old} + \eta(x - w_{ij\_old})$$

Otherwise, update the weight as follows:

$$w_{ij\_new} = w_{ij\_old} - \eta(x - w_{ij\_old})$$

(3) Characteristics of LVQ neural network

Unlike other neural network andLVQneural network can take advantage of the competitive layer neural network automatically learning mode of input vector classification, however, for the classification of the competitive layer for is often just depends on the input vector of the distance between each other, if the distance between the two input vectors are very similar, competitive layer will put them into a class of large probability. However, for the target classification results specified by users of LVQ neural network, the neural network can use supervised learning method to complete accurate prediction classification of input vector mode. Therefore, compared with other models, the advantages of LVQ neural network is the network structure is simple, only needs to be done by the interaction of internal unit can predict classification of complex data processing, in addition, don't need to input vector normalization, orthogonalization processing, also can be applied to pattern recognition, so simple.

3. Experimental procedures and results analysis

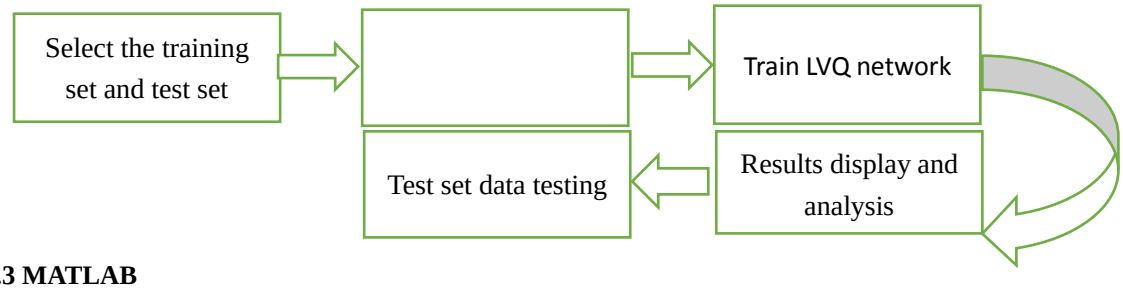
3.1 MATLAB operation ideas

Twelve risk factors of different coronary plaque formation were taken as the input of the network, and four types of plaque (1. non-calcified plaque, 2. mixed plaque, 3.calcified plaque, 4. no plaque) were taken as the input of the network

Network output. The LVQneural network was trained with the training set data, and then the test set data were tested and the test results were analyzed.

3.2 MATLAB operation steps

According to the above design ideas, the design steps mainly include the following:



3.3 MATLAB

3.3.1 Select training set and test set

Data were imported into MATLAB, 280 samples were randomly divided into training sets and test sets, including 250 training sets and 30 prediction sets, and data were normalized and preprocessed . MATLAB code is as follows:

```
A = randperm (280);
Trainwine = wine (a (25 0), :);
Testwine = wine (a (251: the end), :);
[mtrain, ntrain] = size (trainwine);
[mtest, ntest] = size (testwine);
The dataset = [trainwine; testwine];
[datasetscale, ps] = mapminmax (dataset ', 0, 1);
Datasetscale = datasetscale ';
Trainwine = datasetscale (1: mtrain, :);
(mtrain testwine = datasetscale (+ 1) : (mtrain + mtest), :);
Ptrain = trainwine ';
Ptest = testwine ';
Tctrain = wine_labels (a (25 0), :) ';
Ttrain = ind2vec (Tctrain);
Tctest = wine_labels (a (251: the en), :) ';
```

3.3.2 Create LVQ network

After the training set and test set are selected, new lvq function and training set data are used to create the neural network, where the learning rate is 0.01, learnlv1 means the learning method is LVQ1, and MATLAB code is as follows:

```
For I = 1
What {I} = length (find (Tctrain = = I)) / 250;
The end
```

Net = newlvq (minmax (Ptrain), 12, cell2mat (rate), 0.01);
Net. TrainParam. Epochs = 100;
Net. TrainParam. Goal = 0.001;
Net. TrainParam. Lr = 0.01;

3.3.3 train LVQ network

After the network is created, parameters such as iteration number, learning rate and training accuracy are set. Train function is used to train the network, and its MATLAB code is as follows:
Net = "train" (.net, Ptrain, Ttrain);

3.3.4 Test with test set data

After LVQ neural network model training is completed, sim function is then used to input the test set data of coronary artery plaque into the established model [9], and the classification results of coronary artery plaque in the test set can be obtained. Its MATLAB code is as follows:
Tsim = sim (.net, Ptest);
Tcsim = vec2ind (Tsim);
Result = [Tcsim; Tctest];

3.3.5 Results display and analysis

Table 1 Results Collation

Test set Number	Actual Value	Test Value	Test set Number	Actual Value	Test Value
1	4	4	16	4	2
2	4	4	17	4	4
3	4	2	18	4	4
4	4	4	19	4	4
5	2	2	20	4	4
6	4	4	21	4	4
7	3	3	22	4	4
8	4	2	23	4	4
9	4	4	24	3	3
10	4	4	25	4	4
11	4	4	26	4	4
12	4	4	27	3	4
13	4	4	28	4	4
14	4	4	29	4	4
15	4	4	30	4	4

Table 1 shows the display results of Matlab operation. In order to make the results more intuitive, table data results are sorted out.

Table 2 Results Collation

Test set Number	Test Correct	Test Error	Average Correct Rate
30	26	4	86.7%

Results can be seen in table 2, with 30 groups of test data sets, there are four sets of data error diagnosis group (group 3, 8, 16 groups will be misdiagnosed as 2 4, 27 will be 3 misdiagnosed as 4), the average diagnostic accuracy was 86.7% (26/30). The experimental results show that the normalization of data pretreatment combining LVQ neural network can implement the categorization of coronary artery plaque, has certain feasibility.

4. Conclusions and Suggestions

To study the risk factors of different coronary plaque formation and to predict plaque types, we conducted a systematic analysis. In order to predict the types of different coronary plaque, a certain model needs to be established to predict the types of plaque according to the quantitative features in the database. Based on MATLAB, LVQ neural network is used to predict the types of plaque through the risk factor indexes of different coronary plaque formation.

In the clinical treatment, for coronary heart disease, give the following recommendations. Coronary heart disease people should maintain a healthy lifestyle, such as pay attention to a reasonable diet, control the intake of high cholesterol, high fat food, eat more vegetables and fruits, avoid spicy and greasy, smoking alcohol and so on. Also limit total calories. Work and rest should be regular, avoid the spirit of excessive excitement, excessive tension; Get enough sleep and maintain emotional stability. Must strengthen the physical exercise, strengthens the physique. Active prevention and treatment of the elderly chronic diseases: hypertension, hyperlipidemia, diabetes and so on.