NEURAL NETWORKS IN TRANSIENT ISCHEMIC ATTACKS DIAGNOSTICS

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In this paper the neural network model for transient ischemic attacks recognition have been addressed. The proposed approach is based on integration of the NPCA neural network and multilayer perceptron. The dataset from clinic have been used for experiments performing. Combining two different neural networks (NPCA and MLP) it is possible to produce efficient performance in terms of detection and recognition transient ischemic attacks. The main advantages of using neural network techniques are the ability to recognize "novel" TIA attack instances, quickness and ability to assist the doctor in making decision.

Keywords: Transient ischemic attacks, multilayer perceptron, Nonlinear PCA neural network, attacks recognition.

INTRODUCTION

Nowadays the use of Artificial Intelligence has become broadly applied in medicine. Every year in medical journals are issued over 500 academic publications concerning artificial neural networks in medical applications [1]. In accordance with published literature the artificial neural networks are powerful tool for automatic diagnostics of disease with potential to support clinical decision making.

There are different techniques to initial diagnostics of TIA: neuropsychological testing, statistical approach, artificial intelligence approach [3-8]. The main disadvantage of neuropsychological testing is correlation on a doctor qualification and low accuracy. The statistical approach demands large database. The artificial intelligence techniques use neural networks, genetic algorithm, fuzzy logic or combination of abovementioned approaches. Such a technique is characterized with high accuracy and demands not too big data set in comparison with the statistical approach. Therefore artificial intelligence techniques can be appropriate tools for TIA detection and recognition. In this paper we propose neural network model for TIA detection and recognition. Neural networks technique is used to reduce the diagnostic time and the number of misdiagnosis, as well as to assist a doctor in making decision. The database from the 5th city hospital of Minsk was used.

The efficiency of the proposed neural network model in detection and recognition of transient ischemic attacks is illustrated by the experimental results.

RELATED RESEARCHES

At present time there exist different approaches to preliminary diagnostics of TIA. Neuropsychological testing is used for initial evaluation of TIA very often [3]. However neuropsychological testing greatly depends on doctor qualification and therefore is very subjective.

The recognition tool for transient ischemic attack is described in [4]. The authors applied multivariate logistic regression using ROC (receiver operating characteristic curves) analysis to develop clinical scoring system. This system correctly identified 85% of patients with a cerebrovascular diagnosis and 54% with a non-cerebrovascular diagnosis. However such an approach demands the big database.

The neural networks for Ischemic Stroke are presented in [6]. The proposed models were developed for rapid classification into the following outputs: no event, TIA or stroke in left carotid, right carotid, verterobasilar.

In [7-8] the backpropagation neural networks for the prediction of thrombo-embolic stroke are described. The architecture of neural network consists of 20 input units, 10 hidden and 10 output units. The prediction accuracy is 78,52% using training set and 90,61% using testing data set.

The mentioned above neural networks approaches are differed each from other used input and output data, as well as database of patients. Therefore it is very difficult to compare different approaches.

TRANSIENT ISCHEMIC ATTACKS

A transient ischemic attacks (TIA) is a transient episode of neurological dysfunction caused by focal brain, spinal-cord or retinal ischemia without acute infarction [3]. It is result of temporary reduction or cessation of cerebral blood flow in a specific neurovascular distribution due to low flow through a partially occluded vessel, an acute thromboembolic event, or stenosis of a small penetrating vessel. Transient ischemic attacks are named also thrombo-embolic stroke. After TIA the risk of early acute stroke is increased. Therefore the preliminary diagnosis of TIA is of great importance for prevention of acute stroke. However research has shown a high rate of misdiagnosis of TIA [2].

PATIENT DATA

The data from the 5^{th} city hospital of Minsk have been collected about 114 patients who have symptoms of different TIA diseases. 38 parameters have been selected for each patient, such as age, sex, residence, education, trade, conflicts on job, residence change for last 10 years, trade change for last 10 year, features of night dream, sleeplessness, heredity on pathology brain vessels, heredity on other diseases, arterial hypertensia, diastolic pressure, auscultation hearts, heart borders, changes on electrocardiogram, heart pain, cardiac arrhythmia, chronic bronchitis, chronic hepatocholecystitis, chronic gastritis, nephrolithiasis, osteochondrosis, meteodependence, the alcohol use, smoking (amount), smoking (age), working capacity, irritability, memory decline (degree), memory decline (occurrence time), vision acuity decrease (degree), vision acuity decrease (occurrence time), vision disorders, headache (nature), headache (occurrence time), dizziness. The TIA can be classified into 3 classes: TIA1, TIA2 and TIA3. The data set contain 28 patterns of TIA1, 25 patterns of TIA2, 27 patterns of TIA3 and 34 patterns of normal state without TIA.

PROPOSED MODEL

The proposed model is based on two different neural networks. The 38 features mentioned above are used as input vector, which contains information about patient. The output data of neural network model represent the 4-dimensional vector, where 4 are number of TIA classes plus normal state. The data processing consists of two stages. The first stage of data processing is feature selection. The important question concerning input data is the following: which input parameters are really useful and contribute significantly to the performance of neural networks? In this work nonlinear principal component analysis (NPCA neural network) for significant information from data extraction and dimensionality reduction is proposed. It transforms 38-dimensional input vectors into 12-dimensional target vectors.

The second stage of data processing is to detect and to recognize transient ischemic attacks. Compressed on the previous step data contain the useful information from input data and are used as inputs on the second stage of data processing. The multilayer perceptron (MLP) is applied for transient ischemic attacks recognition. Thereby the neural network model consists of two neural networks: NPCA and MLP (Fig. 1).

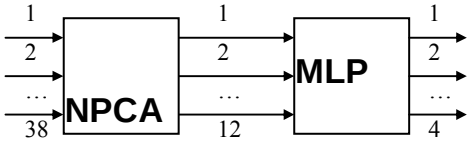

Fig.1. Architecture of the system

Before entering to NPCA the data should transform by the following way:

$$x_i^k = \frac{x_i^k - \mu(x_i)}{\sigma(x_i^k)}, \tag{1}$$

$$\mu(x_i) = \frac{1}{L}\sum_{k=1}^{L} x_i^k, \tag{2}$$

$$\sigma(x_i^k) = \frac{1}{L}\sum_{k=1}^{L} (x_i^k - \mu(x_i))^2, \tag{3}$$

where L is training data set dimension.

After training the neural network model have ability to transient ischemic attacks recognition.

NPCA NEURAL NETWORK

Let's consider an autoencoder, which is also called recirculation or replicator neural network as it is shown in Fig. 2. It is represented by multilayer perceptron, which performs the nonlinear compression of the dataset through a bottleneck in the hidden layer. As we can see the nodes are partitioned in three layers. The bottleneck layer performs the compression of the input dataset.

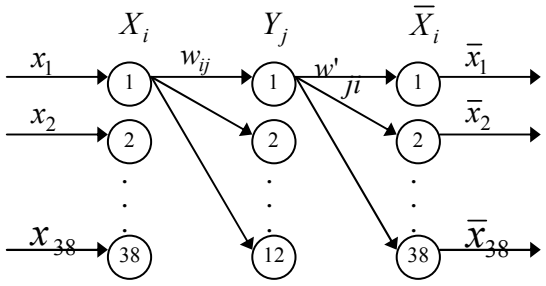

Fig. 2. NPCA neural network

After training the NPCA neural network can perform orthogonal compression of input data set.

MULTILAYER NEURAL NETWORK

As it has been mentioned before the architecture of the neural network for TIA recognition used in this paper is the multilayered feed-forward network with 12 input units, 5 hidden units and 4 output units. The activation function for each unit of hidden and output layers is sigmoid function. The number of hidden layer corresponds to dimension of compressed data and the number of output layer corresponds to number of classes TIA and normal state. The number of hidden layer was defined by experimental way. The backpropagation algorithm is used for training multilayer perceptron. Output value of a neural network is the number in a range from 0 up to 1 which characterizes probability of diagnostics for corresponding class of TIA.

RESULTS AND DISCUSSION

For training and testing proposed neural network model the clinical observations of 114 patients with 38 parameters have been used. The clinical data set contain 28 patterns of TIA1, 25 patterns of TIA2, 27 patterns of TIA3 and 34 patterns of normal state without TIA. At the beginning the experiments with NPCA neural network have been performed using backpropagation algorithm together with the Gram-Schmidt procedure.

Let's consider the mapping of input space data for normal state and TIA classes of attack on the plane of two and three principal components (Fig.3). As can be seen from the Fig. 3 the data, which belong different types of attacks are located in compact areas.

The all data set have been divided into 2 groups: the training data set and testing data set. The recognition accuracy is 100% using training data set and 78% using testing data set (Table).

Recognition Accuracy

Number of patterns in training data set	Number of patterns in testing data set	Recognition accuracy on training data set	Recognition accuracy on testing data set
90	24	100 %	78 %

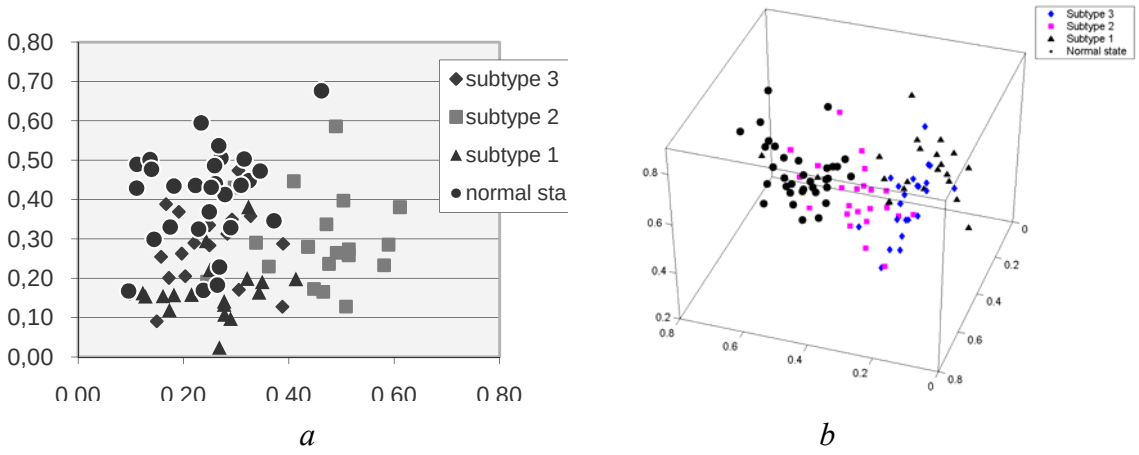

Fig. 3. Data Visualization on plane of two (*a*) and three (*b*) principal components.

CONCLUSION

In this paper the neural network model for transient ischemic attacks recognition have been addressed. The proposed approach is based on integration of the NPCA neural network and multilayer perceptron. The dataset from clinic have been used for experiments performing. Combining two different neural networks (NPCA and MLP) it is possible to produce efficient performance in terms of detection and recognition transient ischemic attacks. The main advantages of using neural network techniques are the ability to recognize 'novel" TIA attack instances and quickness of work which is especially important in the real time mode. Neural networks technique permits to reduce the diagnostic time and the number of misdiagnosis, as well as to assist the doctor in making decision.

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