METHODS OF DIAGNOSIS AND TREATMENT

V.A. Lazarenko, A.E. Antonov, A.V. Prasolov, M.I. Churilin

EVALUATING THE EFFICIENCY OF NEURAL NETWORK PROGNOSIS OF HEALTH QUANTITATIVE INDICATORS IN PATIENTS WITH DISEASES OF THE HEPATOPANCREATODUODENAL ZONE

ABSTRACT

Objective was in the public health study to select and assess practical application possibilities of optimal biosatistical methods for monitoring the functioning of artificial neural networks trained for predicting the quantitative health indicators in patients with hepatopancreatoduodenal zone diseases.

Methods. The study was conducted on materials of 385 patients with hepatopancreatoduodenal diseases who underwent in-patient treatment in hospitals in the city of Kursk. There was used the internally developed information system "System of Intellectual Analysis and Diagnosis of Diseases" (Certificate of State Registration of the Program for Computers n. 2017613090). The application provides functionality for creation, configuration, training and practical application of the artificial neural network, multilayer perceptron. Hyperbolic tangent was used as an activation function.

Results. There is presented the experience of selection and practical application of mathematical methods for controlling the operation of the artificial neural network in assessing the quantitative health indicators in patients with peptic ulcer, cholecystitis and pancreatitis. There is shown the expediency of the primary interpretation of the output layer neuron OUT value where $\mathrm{OUT} \in \mathbb{R} \wedge \mathrm{OUT} \in (-1;\ 1)$ to the scale and units of measurement of the evaluated health indicator with subsequent statistical processing of the array of obtained values. The optimal mathematical methods include: the calculation of the means (and their errors) for the arrays of empirical and resulting from the neural network operation values, with subsequent comparison of the arrays using the χ^2 criterion and determining the significance level α. The next step is to estimate the forecast mean error (ME), the forecast mean square error (MSE), the forecast mean absolute error (MAE), the maximum forecast error for the 99th and 95th normal distribution percentiles, the mean percent error (MPE) and the average absolute percentage error (MPAE). An example of a tabular representation of the analysis data is given.

Conclusion. The most convenient and informative mathematical methods for assessing the operation quality of the artificial neural network predicting the quantitative health indicators in patients with hepatopancreatoduodenal zone diseases are various types of forecast errors (mean error, mean absolute error, mean percentage absolute error, etc.). It is expedient to calculate the maximum absolute error of the forecast (for p = 0.05 and p = 0.01), which increases the visibility of the results, as well as the χ^2 criterion, that allows the estimation of hypothesis' significance that there are no differences between the arrays of calculated and empirical quantitative indicators.

INTRODUCTION

The organization of public health in modern society is based on the systematic approach to decision-making [12, 7, 11]. Adapted mathematical programme complexes [4, 5, 6], as well as management information systems based on the principles of artificial neural networks (ANN), gain importance in questions of predicting health indices in patients with peptic ulcer, cholecystitis and pancreatitis [13, 1, 10]. Such tools are considered as the most promising and convenient due to their ability to process complex data [2, 8], demonstrating signs of cobweb causality [3]. However, intelligent systems require mechanisms to control their functioning.

The purpose of our study was in the public health study to select optimal biosatistical methods for monitoring the functioning of artificial neural networks designed for predicting the quantitative health indicators in patients with hepatopancreatoduodenal zone diseases and assess their practical application possibilities.

MATERIALS AND METHODS

The study involved 385 patients undergoing in-patient treatement in hospitals in the city of Kursk for the hepatopancreatoduodenal zone diseases – peptic ulcer, cholecystitis and pancreatitis. The mathematical apparatus was implemented in the internally developed software – "System of Intellectual Analysis and Diagnosis of Diseases" (Certificate of State Registration of the Program for Computers n. 2017613090). The system possesses functionality to create, configure, and train ANNs of multilayer perceptron type. Hyperbolic tangent was selected as an activation function. The dimension of the input vector of the network was 16. There was used the information on the presence of bad habits, sex, the year of birth, the presence of disability, hereditary factor, the history of occupational hazards, etc. The network included 10–14 neurons in each of the 3 hidden layers. The age of probable hospitalization was used as the main output. Overtraining of the network was monitored by cross-checking method, for which the training set was randomly broken into two parts. The information on 355 patients was used for training, and control was carried out on the material of 30 clients.

RESULTS AND DISCUSSION

The activation function – the hyperbolic tangent takes the values $\mathrm{OUT} \in \wedge \mathbb{R} \wedge \mathrm{OUT} \in (-1;\ 1)$ that in this form cannot be interpreted by the user for evaluation of quantitative patient's health indexes. The obtained value (y) can be adapted using the statistics of the training set according to the formula (1):

$$y_{dN} = y \times \max(z_{\max} - Mz, Mz - z_{\min}) + Mz,$$

where Mz, z_{max} and z_{min} – respectively, the mean, maximum and minimum values of this output in the training set.

The adapted value of y_{dN} is quite suitable for further practical processing and has the same units of measure as the output of the training set, for example, years. Nevertheless, this value needs statistical verification. In our study, we applied the following calculated indexes:

1. The standard error mz of the mean

empirical Mz, calculated from the objective data of the output z of the training set.

2. The average calculated My_{dN} and its standard error my_{dN} are determined on the base of the values of the y_{dN} obtained as a result of the ANN operation. Calculations of the means and their standard errors are conducted traditionally.

3. The χ^2 criterion was chosen to confirm or refute the hypothesis that there is no difference between the empirical and forecasted indexes in the sample population. Calculation of the criterion is carried out according to the formula (2):

$$\chi^2 = \sum \frac{(z - y_{dN})^2}{y_{dN}}$$

Where z – empirical values of the index, y_{dN} – the predicted value of the index.

The significance of the hypothesis (α) is estimated by the comparison of the criterion χ^2 with the critical points known from the tables for the degree of freedom $k = n - 1$.

4. The forecast mean error is calculated as the arithmetic mean of the difference between the empirical and predicted value of the studied quantitative index (with changes from [9]) (3):

$$ME = \frac{\sum d}{n}$$

where $d = z - y_{dN}$.

The sign of this indicator allows assessing whether the forecast is too high or too low, and its absolute value indicates the size of the error.

5. The forecast mean square error MSE allows to evaluate the operation of the ANN as a whole and is calculated as (4):

$$MSE = \frac{\sum d^2}{n}$$

6. The forecast mean absolute error MAE is calculated similarly to ME using formula (5):

$$MAE = \frac{\sum |d|}{n}$$

For MAE, it is possible to calculate the standard error mMAE according to the general rules.

7. The MAE and mMAE values obtained in the previous calculation stage are useful for calculating the visually useful value – the maximum absolute forecast errors $|d_{max99}|$ (6) and $|d_{max95}|$ (7):

$$|d_{\max 99}| = MAE + zp_{99} \times mMAE$$

$$|d_{\max 95}| = MAE + zp_{95} \times mMAE$$

where zp_{99} и zp_{95} – 99th and 95th percentiles of the standard normal distribution, respectively.

$|d_{max99}|$ and $|d_{max95}|$ are numbers that do not exceed the forecast absolute error |d| with a probability of 99 or 95%.

8. The mean percentage error MPE, like ME, allows estimating the prediction offset (8).

$$MPE = \frac{\sum \frac{d}{z}}{n} \times 100$$

For properly trained ANN |MPE| should not exceed 5%.

9. The mean percentage absolute error MPAE is similar to MAE, but allows estimating the error in the scale of the index (9).

$$MPAE = \frac{\sum \frac{|d|}{z}}{n} \times 100$$

If MPAE ≤ 10%, the prediction accuracy is considered high, if 10% < MPAE ≤ 20% – good, if 20% < MPAE ≤ 50% – satisfactory and if MPAE > 50% – unsatisfactory. MPE and MPAE are normalized and therefore can be used to compare ANN outputs that have unequal units of measurement and scale, as well as to compare different ANNs.

It is possible to use both the entire training set and a subset with smaller number of units for statistical evaluation of the ANN operation quality. If the latter case the units for calculation are selected randomly.

The results of the calculation can be presented in the form of a table similar to Table. 1. Such presentation of the analysis' results allows the researcher lacking special mathematical knowledge to get acquainted with the evaluation of the quality of the ANN training in a visual form, and also to monitor the operation of the trained network in clinical conditions.

The results of the ANN training for forecasting the age of probable hospitalization in patients with hepatopancreatoduodenal zone diseases, n = 385

Index	Age of probable hospitalization
Mean empirical, Mz, years	52,86
Standard error, mz, years	0,83
Mean calculated, MydN, years	53,31
Standard error, mydN, years	0,83
χ2 criterion	47,13
Significance level, α	≤0,001
Forecast mean error , ME, years	−0,45
Forecast mean square error, MSE, years 2	6,02
Forecast mean absolute error, MAE, years	1,87
Standard error of MAE, mMAE, years	0,08
The error of the forecast will not exceed (p95 percentile), years	2,00
The error of the forecast will not exceed (p99 percentile), years	2,06
Mean percentage error, MPE, %	−1,01
Mean percentage absolute error, MPAE, %	4,03

CONCLUSION

The most convenient and informative mathematical methods for assessing the operation quality of the ANN predicting the quantitative health indicators in patients with hepatopancreatoduodenal zone diseases are various types of forecast errors (mean error, mean absolute error, mean percentage absolute error, etc.). It is expedient to calculate the maximum absolute error of the forecast (for p = 0.05 and p = 0.01), which increases the visibility of the results, as well as the χ^2 criterion, that allows the estimation of hypothesis' significance that there are no differences between the arrays of calculated and empirical quantitative indicators.

REFERENCES

1. Chubukova I.A. Data Mining. Moscow: BINOM. Laboratorija znanij [Laboratory of knowledge], 2008, 324 p.

2. Gorohova S. At'kov O. Sboev A. et al. Novye tehnologii prognozirovanija riska razvitija IBS [New technologies for predicting the risk of coronary heart disease]. Vrach [The doctor]. 2011, 14, pp. 22–25.

3. Konstantinova E.D. Varaksin A.N. Zhovner I.V. Opredelenie osnovnyh faktorov riska razvitija neinfekcionnyh zabolevanij: metod derev'ev klassifikacii [Identification of the main risk factors for non infectious diseases: method of classification trees]. Gigiena i sanitarija [Hygiene and sanitary]. 2013, 5, pp. 69–72.

4. Lazarenko V.A. Antonov A.E. Novomlinec Ju.P. Vizual'naja sreda neparametricheskogo korreljacionnogo analiza faktorov riska u bol'nyh s hirurgicheskoj patologiej [Visual environment for non-parametric correlation analysis of risk factors in patients with surgical diseases]. Zhurnal nauchnyh statej Zdorov'e i obrazovanie v XXI veke [The journal of scientific articles Sscience and education millenium]. 2017, 19 (4), pp. 34-37.

5. Lazarenko V.A. Antonov A.E. Prasolov A.V. Churilin M.I. Problema optimizacii regressionnogo analiza

v ocenke faktorov riska, vlijajushhih na razvitie hirurgicheskih zabolevanij gepatopankreatoduodenal'noj zony [The problem of regression analysis optimization in evaluation of risk factors influencing the development of surgical diseases of hepatopancreatoduodenal zone]. Zhurnal nauchnyh statej Zdorov'e i obrazovanie v XXI veke [The journal of scientific articles Sccience and education millenium]. 2017, 19 (5), 24-27.

6. Lazarenko V.A. Antonov A.E. Rol' social'nyh faktorov riska v razvitii jazvennoj bolezni v kurskoj oblasti [The Role of Social Risk Factors in Peptic Ulcer Development in Kursk Region]. Kurskij nauchno-prakticheskij vestnik "Chelovek i ego zdorov'e" [Kursk Scientific and Practical Bulletin "Man and His Health"]. 2016, 2, pp. 35-39. DOI: 10.21626/vestnik/2016-2/06.

7. Lopuhova V.A. Tarasenko I.V. Kajlanich G.A. Kajlanich E.A. Izuchenie kachestva vnebol'nichnoj medicinskoj pomoshhi v medicinskih organizacijah goroda Orla [The study of outpatient care quality in medical institutions of the Orel-city]. Sovremennye problemy nauki i obrazovanija [Modern problems of science and education]. 2016, 5. [Electronic resource] http://www.science-education.ru/ru/article/view?id=25383. (Accessed on: 28.11.2016).

8. Mustafaev A.G. Primenenie iskusstvennyh nejronnyh setej dlja rannej diagnostiki zabolevanija saharnym diabetom [Use of artificial neural networks in early diagnosis of diabetes mellitus disease]. Kibernetika i programmirovanie [Cybernetics and programming]. 2016, 2, pp. 1–7. DOI: 10.7256/2306-4196.2016.2.17904.

9. Pokazateli tochnosti prognoza [Indexes of prognosis accuracy] [Electronic resource].– http://studopedia.ru/17_33823_pokazateli-tochnosti-prognoza.html (Accessed on: 28.03.2017).

10. Shhepin V.O. Rastorgueva T.I. Proklova T.N. K voprosu o perspektivnyh napravlenijah razvitija zdravoohranenija Rossijskoj Federacii [Towards prospective directions of healthcare development in the Russian Federation]. Bjulleten' Nacional'nogo nauchno-issledovatel'skogo instituta obshhestvennogo zdorov'ja imeni N.A. Semashko [Russian academy of medical sciences. Bulletin of National research institute of public health]. 2012, 1, pp. 147–152.

11. Simonyan R.Z. Kailanich G.A. Lopukhova V.A. Tarasenko I.V. Izuchenie kachestva medicinskoj pomoshhi pri ocenke tehnologij zdravoohranenija [The study of medical care quality in the health technology assessment]. Mezhdunarodnyj zhurnal prikladnyh i fundamental'nyh issledovanij [International journal of applied and fundamental research]. 2016, 8, pp. 185-187.

12. Svetyy L.I. Lopukchova V.A. Tarasenko I.V. Klimkin A.S. Primenenie sistemy ocenki tehnologij zdravoohranenija v prinjatii jeffektivnyh upravlencheskih reshenij [The use of health technology assessment in making effective management decisions]. Zhurnal nauchnyh statej Zdorov'e i obrazovanie v XXI veke [The journal of scientific articles Sccience and education millenium]. 2013, 15 (1-4), pp. 234-235.

13. Zharikov O.G. Jekspertnye sistemy v medicine [Expert systems in medicine]. Meditsinskie novosti [Medical News]. 2008, 10, pp. 15–18.

Information about authors

Lazarenko V.A., MD, MMed, PhD habil., MBA, Professor, Rector of FSBEI HE "Kursk State Medical University" of the Ministry of Healthcare of the Russian Federation, kurskmed@mail.ru; 305041, 3, K. Marx str., Kursk, Russia. Tel.: +7 (4712) 588-132, fax: +7 (4712) 56-73-99.

Antonov A.E., MD, MMed, PhD, MPH, Assistant to the Rector for General Issues, Associate Professor of the Department of Surgical Diseases of the Faculty of Postgraduate Education of FSBEI HE "Kursk State Medical University" of the Ministry of Healthcare of the Russian Federation, drantonov@mail.ru; 305041, 3, K. Marx str., Kursk, Russia. Tel.: +7 (4712) 588-132.

Prasolov A.V., MD, MMed, PhD habil. Head of the Division of Health Monitoring Regional State State-owned Health Institution of Special Type "Regional Center of Medical Prevention", city of Belgorod, drdeath@mail.ru; 308034, 15 в, Gubkina str., Belgorod, Russia. Tel. +7 (4722) 32-36-85.

Churilin M.I., DrPH, Assistant Professor of the Department of General Education of FSBEI HE "Kursk State Medical University" of the Ministry of Healthcare of the Russian Federation, churilinmi@kursksmu.net; 305041, 3, K. Marx str., Kursk, Russia. Tel.: +7 (4712) 587-799.

V.G. Banzaraksheev, Ya.G. Razuvaeva

PATHOMORPHOLOGICAL AND PATHOPHYSIOLOGICAL EVALUATION OF LIVER CHANGES IN WHITE RATS WITH EXPERIMENTAL DYSLIPIDEMIA AND ITS CORRECTION

ABSTRACT

In the experiment, a morphofunctional assessment of liver changes in rats with dyslipidemia and its phytotherapeutic correction was performed. It was found that the appointment of an atherogenic diet is accompanied by an increase in the total blood cholesterol, triglycerides, low density lipoproteins cholesterol and a decrease in the level of high density lipoproteins cholesterol. Against this background, the liver develops pathomorphological changes in the form of fatty hepatosis, necrobiosis and circulatory disorders. In addition, an increase in malonic dialdehyde concentration and inhibition of catalase activity are observed in rats liver homogenates. At the same time, the course introduction of phytoremedy normalizes the lipid metabolism, raises the activity of catalase in liver homogenates and reduces the content of malonic dialdehyde, and also reduces the severity of pathomorphological changes in the liver. Apparently, the polyvalent effect of phytoremedy is due to the content in its components of a complex of biologically active substances that exert lipid-lowering, antioxidant and hepatoprotective effects.

Keywords: dyslipidemia, hepar, lipid peroxidation, phythoremedy.

INTRODUCTION

In the 21st century the steady growth of atherosclerosis-associated cardiovascular pathology continues to be the main problem of Healthcare all over the world including Russia [2]. Besides, in many regions dyslipidemia is a common and significantly modified risk factor of atherosclerosis [6]. It is well known that the pathophysiological role of dyslipidemia, regardless of its etiology and pathogenesis, lies in its injuring