Methods for predicting the assessment of the quality of educational programs and educational activities using a neuro-fuzzy approach

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Abstract

In the process of self-assessment and accreditation examination, assessment is carried out according to a scale that covers four levels of compliance with the quality criteria of the educational program and educational activities. Assessing the quality of education is complicated by the fact that the value of quality criteria is due to a large number of factors, possibly with an unknown nature of influence, as well as the fact that when conducting pedagogical measurements it is necessary to work with non-numerical information. To solve these problems, the authors proposed a method for assessing the quality of educational programs and educational activities based on the adaptive neuro-fuzzy input system (ANFIS), implemented in the package Fuzzy Logic Toolbox system MATLAB and artificial neural network direct propagation with one output and multiple inputs. As input variables of the system ANFIS used criteria for evaluating the educational program. The initial variable of the system formed a total indicator of the quality of the curriculum and educational activities according to a certain criterion or group of criteria. The article considers a neural network that can provide a forecast for assessing the quality of educational programs and educational activities by experts. The training of the artificial neural network was carried out based on survey data of students and graduates of higher education institutions. Before the accreditation examination, students were offered questionnaires with a proposal to assess the quality of the educational program and educational activities of the specialty on an assessment scale covering four levels. Student assessments were used to form the vector of artificial neural network inputs. It was assumed that if the assessments of students and graduates are sorted by increasing the rating based on determining the average grade point average, the artificial neural network, which was taught based on this organized data set, can provide effective forecasts of accreditation examinations. As a result of comparing the initial data of the neural network with the estimates of experts, it was found that the neural network does make predictions quite close to reality.

Keywords

evaluation criteria, educational program, educational activities, prognostication, rating, ANFIS, artificial neural networks

1. Introduction

In assessing the quality of education, as well as in conducting pedagogical research, we are faced with information that has non-numerical characteristics that are difficult to formalize. For example, the number of computers, the number of students, the area of educational premises in a higher education institution are measurable, but the evaluation of the educational program and educational activities according to the educational program is carried out according to non-numerical criteria. The institution in the process of self-assessment, and subsequently the experts in the process of accreditation examination, must assess according to the assessment scale, which covers four levels of compliance with the criteria: A, B, E, F.

As a result, there is a need to build methods for quantitative description of processes and subjects related to assessing the quality of the educational program and educational activities. Of particular importance is the quality of education, which means some total indicator that reflects the results of the educational institution, as well as compliance with the needs and expectations of society (different social groups) in the formation of individual competencies. The methods of quantitative evaluation of the educational program and educational activities under this program will allow the higher education institution to identify existing shortcomings and potential problems, as well as provide an opportunity to address them before the accreditation examination.

Assessing the quality of educational programs and educational activities is complicated by the fact that the value of this indicator depends on many factors, possibly with an unknown nature of influence. Also in this case there is a specificity of the "product" of education – a graduate of an educational institution, which should be considered as a complex system. There are various methods and algorithms for assessing the quality of educational activities. In this study, we propose a method of assessing the quality of educational programs and educational activities based on the neuro-fuzzy approach, due to the active development of analytical systems, based on the technology of artificial intelligence. The most popular and proven of these technologies are neural networks, which successfully solve a variety of "fuzzy" tasks – prediction, classification, recognition of handwritten text, language, images [1, 2, 3, 4, 5, 6]. In such problems, where traditional technologies are powerless, neural networks often act as the only effective solution. In this work, artificial neural networks are used to solve the problem of assessing the quality of educational programs and educational activities.

Mandatory conditions for accreditation are compliance with the educational program and educational activities of the higher education institution under this educational program with the

CTE 2021: 9th Workshop on Cloud Technologies in Education, December 17, 2021, Kryvyi Rih, Ukraine
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criteria established by law. In particular, the forms and methods of teaching should contribute to the achievement of the stated goals of the educational program and program learning outcomes.

Since the educational program and educational activities must meet the requirements of a student-centered approach and the principles of academic freedom, the hypothesis of the study is that based on a sample of students and graduates of higher education, the quality of educational programs and educational activities, which will be able to adequately perform a comprehensive assessment of the quality of the educational program and educational activities.

Intelligent data processing using a neural network allows forming forecast probabilities of values of future results of accreditation examination in a higher education institution, which can contribute to the improvement of measures to improve the educational program. The results of forecasting can be used by the management of faculties and graduating departments as informative and recommendatory. In addition, guarantors of educational programs based on forecasts can plan activities and individual work with teachers to positively change the forecast. Thanks to the analysis of the received data it is possible to reveal weak points of the educational process that will give the chance to modernize it.

With this in mind, the article aims to substantiate, develop and implement a mathematical model of a comprehensive assessment of the quality of educational programs and educational activities based on the methods of the neuro-fuzzy approach.

1.1. Theoretical background

Assessing the quality of educational activities according to clearly defined criteria and methodologies is an important task in the process of accreditation of educational programs, which are used to train applicants for higher education in Ukraine. In the process of preparing for accreditation and preparation of materials for self-assessment of the educational program, there are problems in determining the objectivity of self-assessment and finding potential problems and shortcomings of educational activities. Due to this problem, the urgent task is to find mathematical tools that could be used by managers of higher education institutions in their approaches to determining the quality of educational services offered.

The paradigm shift in educational philosophy and practice has led to focusing primarily on student learning outcomes. The educational process should be results-oriented - what exactly students know and can actually do. Accordingly, student-centered learning is an approach in which students influence the content, activities, materials, and pace of their learning. This model of learning puts the student at the center of the learning process [7].

EU initiatives call for increased efficiency, international attractiveness, and competitiveness of higher education institutions. A study by Wächter et al. [8] considers different approaches to quality, quality assurance, and ratings, analyzes recent research, critically analyzes these approaches in a comparative perspective, provides recommendations and policy options for parliament.

The problem of determining a set of effective indicators that are easy to determine and can be applied to both large public universities and small regional private colleges, from university programs to alternative programs is also relevant for the United States [9].

Cherniak et al. [10] investigated the possibility of assessing the quality of qualimetry objects by graph analytical method, ie to apply the principle of determining the area and volume under curved surfaces both in the plane and in space, which are created by combining estimates of individual quality indicators on a dimensionless scale. It is shown that, as a rule, mathematical dependences are nonlinear and their research is reduced to the development of universal methods that could be applied to objects of qualimetry, regardless of their nature, complexity, importance, and more. Having unit quality indicators in a single (dimensionless) rating scale, it is proposed to determine a single comprehensive quality indicator of the object of qualimetry using the method of integration, which takes into account the evaluation of unit quality indicators [10].

Pârvu and Ipate [11] propose a mathematical model based on a set of indicators that are adapted to the classification structure of intellectual capital, which is unanimously recognized worldwide, namely to the external and internal structure and competence of employees. The Rompedet method, an original product of the Romanian school of management [12], was used as a mathematical calculation tool.

When assessing the quality of education, we are faced with a huge number of different criteria, each of which may consist of many sub-criteria, therefore, the task of assessing the quality of education in its mathematical formulation is multi-criteria. Problem situations that are modeled and described by linear models and depend on many factors play an important role, so solving a multicriteria decision-making problem is often accompanied by solving multicriteria linear programming problems, or in other words, vector optimization problems.

Given these problems, mathematical models of integrated quality assessment using methods that are based on the convolution of criteria were also of interest for our study. Models and methods of multicriteria optimization are considered in the work of Kondruk and Malyar [13], in particular, the method of additive convolution of criteria and the method of multiplicative and minimax convolution of criteria. The method of multiplicative convolution of partial criteria to a single generalized indicator, which provides as a normalized divisor to use the maximum (minimum) values of partial criteria, obtaining which does not cause significant difficulties, ie is carried out on many available design solutions is considered in [14]. Chervak [15] uses one of the methods of solving the Paretian multicriteria optimization problem as a mathematical tool of the decision-making process. To organize the selection problems on the same admissible set of alternatives, the concept of the super criterion of any criterion is introduced; if the criterion is a super criterion of this criterion on this set, then the last criterion is a subcriteria of the first. It is shown that the solution of the problem of multicriteria selection by the Paretian convolution is reduced to the solution of the problems of scalar or lexicographic optimization.

The theory of artificial neural networks and models of deep learning is considered in the fundamental works of Goodfellow et al. [16], Müller et al. [17], Sivanandam et al. [18], system design based on a neuro-fuzzy approach [19, 20].

The use of neural networks to classify the status of a graduate of a higher education institution based on selected academic, demographic, and other indicators is considered by Lesinski et al. [21]. A multilayer neural network with feedback is used as a model. The model was taught based on more than 5,000 records of entrance exams and university databases. Nine input variables consisted of categorical and numerical data that contained information about high school education, test results, assessment of high school teachers, parental assessment, and others. Based on these inputs, the multilayer neural network predicted the success of university entrants. With the help of the neural network, it was possible to predict the success of graduates and achieve the best performance with an accuracy of classification exceeding 95%. Black et al.

[7] examining the relationship between quality and success of high school students in college found no convincing evidence that exposure characteristics of high school diminish over time teaching students.

To address the issue of determining the quality of educational training, Mahapatra and Khan [22] developed the EduQUAL methodology and proposed an integrative approach using neural networks to assess the quality of education. Four neural network models based on a feedback algorithm are used to predict the quality of education for different stakeholders. This study showed that the P-E Gap model is the best model for all stakeholders [22].

The need to introduce neural network technology in educational courses of educational institutions indicates by Belyux and Sitkar [23]. Educational neural networks are often used for forecasting. For example, students must choose courses that interest them for the next semester. Due to limitations, including lack of sufficient resources and the overhead of several courses, some universities may not be able to teach all courses of the student's choice. Universities need to know each student's requirements for each course each semester for optimal course planning. Kardan et al. [24] used a neural network to model student choice behavior and apply the resulting function to predict the final enrollment of students for each course. The results showed high prediction accuracy based on experimental data. Arsad et al. [25], Osadchyi et al. [26], Okubo et al. [27] prove that the use of neural networks in predicting educational processes will allow obtaining results with a much higher level of accuracy and less time. According to Naser et al. [28], an artificial neural network can correctly predict the success of more than 80% of future students.

Chaban and Kukhtiak [29] analyze the problem of the social system, which consists of many students and teachers of higher education to create effective learning pairs "teacher-student". Elements of the theory of artificial intelligence based on artificial neural networks were used to form the mentioned learning pairs. Bukreyev and Serdyuk [30] propose to use a recurrent neural network (RNN) to predict students' final grades using journal data stored in educational systems.

Liu et al. [31] propose a method for assessing the quality of preparation for graduate school, which is based on the algorithm of neural network backpropagation and stress testing. This method creates a publicly available list of indicators consisting of 19 criteria in 4 groups of criteria, such as attitudes towards teaching, teaching content, approach to teaching, and the main characteristics of teachers. After the neural network algorithm is used to determine the optimal parameters of the evaluation model, a sensitivity test is used to identify indicators that have a significant impact on the quality of education. Also, scenario analysis is used to study the impact of the quality of education in pre-defined situations, providing theoretical and empirical support for assessing the quality of postgraduate teaching, improving the quality of education, and professional growth of teachers [31].

Educational institutions are constantly striving to improve the services they offer, their goal is to have the best teaching staff, improve the quality of teaching and academic success of students. Knowledge of the factors influencing student learning can help universities and learning centers adapt their curricula and teaching methods to students' needs. One of the first measures taken by educational institutions in the context of the COVID-19 pandemic was the creation of virtual learning environments [32]. To understand the factors influencing the university learning process in virtual learning environments, Rivas et al. [33] applied several automatic learning methods to publicly available data sets, including tree-like models and various types of artificial neural networks.

The availability of educational data supported by learning platforms provides opportunities to study student behavior and solve problems in higher education, optimize the educational environment and ensure decision-making using an artificial neural network [34].

Cader [35] uses a deep neural network to assess students' acquisition of knowledge and skills. It is noted that the obstacle to the application of the method in teaching is the relatively small amount of data in the form of available estimates required for neural network training. A new method of data augmentation is proposed – asynchronous data augmentation through pre-categorization, which solves this problem. Using the proposed method, it is possible to carry out neural network training even for small amounts of data [35].

Do and Chen [36] present a neuro-fuzzy classifier that used the results of previous exams and other related factors as input variables and classified students based on their expected learning outcomes. The results showed that the proposed approach achieved high accuracy compared to the results obtained based on other known approaches to classification, in particular, Naive Bayes, neural networks, and others.

Fazlollahtabar and Mahdavi [37] proposed a neuro-fuzzy approach based on evolutionary techniques to obtain the optimal learning pathway for both teacher and student. The neuro-fuzzy approach allows providing recommendations to the teacher for making pedagogical decisions based on the student's learning style. On the other hand, the neural network approach is used for the student to create a personalized curriculum profile based on the individual needs of the student in a fuzzy environment [37].

Taylan and Karagözoğlu [38] use a systematic approach to designing a fuzzy inference system based on a class of neural networks to assess student achievement. The developed method uses a fuzzy system, supplemented by neural networks, to enhance some of its characteristics, such as flexibility, speed, and adaptability, called the adaptive fuzzy inference system (ANFIS). The results of the ANFIS model are as reliable as statistical methods, but they encourage a more natural way of interpreting student learning outcomes.

In comparison with these works, this study fills a gap in the methods of a comprehensive assessment of the quality of educational programs and educational activities based on a neuro-fuzzy approach.

1.2. Methods

In this study, methods of mathematical modeling and computational experiment based on statistical processing of data assessments of the quality of educational programs and educational activities were used. The essence of the methodology of mathematical modeling is to replace the original object with its mathematical model and study it with the help of computer technology. Processing, analysis, and interpretation of calculation results were carried out by constant comparison with the results of statistical processing of expert estimates. In the course of the research, refinements were made and the mathematical model was revised and the cycle of the computational experiment was repeated.

The methodology for assessing the quality of the curriculum and educational activities is built using methods and tools of artificial intelligence, implemented in the package Fuzzy

Logic Toolbox system MATLAB in the form of adaptive neuro-fuzzy output ANFIS (Adaptive Neuro-Fuzzy Inference System).

Participants in the experiment – full-time master's students (22 people) and graduates of higher education institutions of the previous term of study are the same specialties (32 people) – a total of 54 people. This number of respondents is due to the number of indicators of quality criteria because the data format of the artificial network in MATLAB supports square matrices, in this case, 54x54. Before the accreditation examination, students were offered questionnaires with a proposal to assess the quality of the educational program and educational activities of the specialty on an assessment scale covering four levels: F, E, B, A. Student assessments were used to form the vector of artificial neural network inputs. After the accreditation examination, the expert assessments were used to check the quality of the prediction of the artificial neural network.

To ensure the representativeness of the sample, the study of its design was carried out based on randomization. The decision on the statistical deviation of the null hypothesis regarding the differences between the averages, thus, was also associated with the procedure of random sampling.

The rating scale covers four levels of compliance by the requirements of the legislation (F, E, B, A) [39]. Also, the legislation establishes 10 criteria for assessing the quality of the educational program [39]:

1) design and objectives of the educational program (4);
2) structure and content of the educational program (9);
3) access to the educational program and recognition of learning outcomes (4);
4) teaching and learning according to the educational program (5);
5) control measures, evaluation of applicants for higher education and academic integrity (4);
6) human resources (6);
7) educational environment and material resources (6);
8) internal quality assurance of the educational program (7);
9) transparency and publicity (3);
10) learning through research (6).

In turn, each of these criteria has from 3 to 9 indicators (the number is indicated in parentheses). Together, all 10 criteria contain 54 indicators.

2. Results

At the first stage of the study, the collection and statistical processing of data on the results of the assessment of students and graduates of higher education educational programs and educational activities on the educational program for each criterion.

In the second stage, a computational experiment was performed. The cycle of the computational experiment was carried out in several stages:

1) the choice of approximation and mathematical formulation of the problem (construction of a mathematical model of the phenomenon under study);

2) development of a computational algorithm for solving the problem;
3) implementation of the algorithm in the form of a program for the PC;
4) settlements on the PC;
5) processing, analysis and interpretation of calculation results, comparison with the results of statistical processing of expert estimates and, if necessary, refinement or revision of the mathematical model, i.e. return to the first stage and repeat the cycle of the computational experiment.

Assessing the quality of the curriculum and learning activities is complicated by the fact that each of the 10 criteria, in turn, consists of several indicators (3-9) and is due to many factors, possibly with an unknown nature of influence, which is also non-numerical. To assess the quality of the curriculum and training activities, it is proposed to use a two-tier system based on the ANFIS package and artificial neural networks to predict assessment scores.

The ANFIS hybrid system is a combination of the Sugeno neuro-fuzzy inference method with the ability to train a five-layer artificial neural network (ANN) of direct propagation with a single output and multiple inputs, which are fuzzy linguistic variables. As input variables of the ANFIS system, we use the criteria for evaluating the quality of the educational program of 10 groups of factors $V_i(i = 1, ..., 10)$.

The output variable of the ANFIS system is a numerical assessment of the quality of the curriculum and training activities and is defined as a function $y = f(V_1, V_2, V_3, V_4, V_5, V_6, V_7, V_8, V_9, V_10)$.

Layer 1 of the ANFIS system for the linguistic evaluation of input parameters uses the term set of all possible values of the linguistic variable. $A_{Vi} = \{“F”, “E”, “B”, “A”\}$. In symbolic form we write: $A_{Vi} = \{F < i >, E < i >, B < i >, A < i >\}$. The term set of the original linguistic variable y is the set of values of quality assessments of the curriculum and educational activities: $T_y = \{F, E, B, A\}$. The outputs of the nodes of layer 1 are the values of the membership functions at specific values of the input variables.

Layer 2 is non-adaptive and defines the preconditions of fuzzy production rules. Production rules – a form of representation of human knowledge in the form of a sentence type – if (condition), then (action). The rules provide a formal way to present recommendations, guidance, or strategies. They are ideal in cases where the knowledge of the subject area arises from the empirical associations accumulated during the work on solving problems in a particular field.

Each node of this layer is connected to those nodes of layer 1, which form the prerequisites of the corresponding rule. To solve this problem, four fuzzy production rules are formulated: $P = \{p_1, p_2, p_3, p_4\}$, because according to the features of the ANFIS network, the number of network rules must correspond to the dimension of the term set of the source variable y.

Nodes perform a fuzzy logical operation “I” (min). The outputs of the nodes of this layer are the degree of truth (fulfillment) of the preconditions of each of the four fuzzy production rules, which are calculated by the formulas:

$$\begin{cases} w_1 = \min(\mu_{F1}(V_1), \mu_{F2}(V_2), \mu_{F3}(V_3), \mu_{F4}(V_4)) \\ w_2 = \min(\mu_{E1}(V_1), \mu_{E2}(V_2), \mu_{E3}(V_3), \mu_{E4}(V_4)) \\ w_3 = \min(\mu_{B1}(V_1), \mu_{B2}(V_2), \mu_{B3}(V_3), \mu_{B4}(V_4)) \\ w_4 = \min(\mu_{A1}(V_1), \mu_{A2}(V_2), \mu_{A3}(V_3), \mu_{A4}(V_4)) \end{cases} \quad (1)$$

Layer 3 normalizes the degree of implementation of each of the fuzzy production rules (calculation of the relative degree of implementation of the rules) as follows:

$$\overline{w}_h = \frac{w_h}{\sum_{i=1}^{h} w_i} \tag{2}$$

where $h = 1, \ldots, 4$ is production rule number. Layer 4 calculates the contribution of each fuzzy production rule to the output of the network according to the formula.

$$y_h(v, V) = \overline{w}_h(v_h^{(0)} + v_h^{(1)}V_1 + v_h^{(2)}V_2 + v_h^{(3)}V_3 + v_h^{(4)}V_4 + v_h^{(5)}V_5) \tag{3}$$

where $v_h^{(0)}$ - coefficients of the initial function ($i = 0, \ldots, 5$).

Layer 5 summarizes the contributions of all the rules:

$$y = \sum_{i=1}^{4} y_i \tag{4}$$

Training of the ANFIS network was carried out for 24 epochs by a hybrid method. During training, the type of membership functions, the type of initial function, and their coefficients are selected. As a result of training a fuzzy network for four rules, Gaussian functions were adopted as membership functions, and a linear function was adopted as the initial function. As a result of training, membership functions and their coefficients were also obtained.

To assess each of the 10 groups of factors that affect the quality of the curriculum and educational activities by the evaluation criteria, 10 modules are used, which are implemented using artificial neural networks. Thus, it is necessary to design neural networks, a mathematical model of a comprehensive assessment of the quality of the educational program and educational activities based on the methods of the neuro-fuzzy approach. For this purpose, the Neural Network Toolbox was used. To form neural networks, it is necessary to determine their topology, learning mechanism, and testing procedure. Also, the training of an artificial neural network requires input data – a sample of answers of students and graduates with reliable quality indicators, determined based on these criteria.

An artificial neural network for the analysis of indicators of the quality of the educational program and educational activities will have the number of input neurons (according to the number of indicators for all criteria) 54; output neurons – 54. Input signals were determined based on students' assessments of each indicator of this quality criterion, while the scale F, E, B, A were translated into numerical 1; 2; 3; 4 respectively. Part of the data is given in table 1.

It is important that the neural network can predict expert assessments if student and graduate assessments are to be ranked in ascending order based on the determination of the grade point average. According to the hypothesis, we assume that students with higher academic performance are better acquainted with the goals, structure, and content of the educational program, the process and characteristics of teaching and learning according to the educational program, control measures, assessment system, and all other aspects of educational activities. assessments of the quality of the educational program and educational activities will be more objective.

Table 1
Input signals (T) based on students' assessments of quality criteria.

Indicators of quality criteria	Student grades								
	1	2	3	4	5	6	7	...	54
1	3	4	3	3	4	3	4	...	4
2	4	3	3	3	4	3	3	...	4
3	3	3	4	3	4	4	3	...	4
...	...	...	...	...	...	...	...	...	...
54	4	3	3	3	4	3	3	...	4

After starting the MATLAB system, you need to enter the tool command on the command line, which will open the window for entering data and creating a neural network (Neural Network / Data Manager). Clicking the New button opens the Create Network or Data window. After selecting the Data tab in the Name field you must enter a new name of the input data "P", and in the Value field the values of the input data, in which the numbers 1-54 are indicators of quality criteria, and 55-108 – students' and graduates' indicators quality criteria.

The configuration of the neural network of direct propagation is chosen based on a heuristic rule: the number of neurons of the hidden layer is equal to half of the total number of input and output neurons. The artificial neural network for the analysis of quality indicators of the educational program and educational activity will have the number of input neurons 2 (according to the dimensionality of the data – indicators of quality criteria and student evaluation); source neurons 54, therefore, the number of hidden neurons is 28 (figure 1).

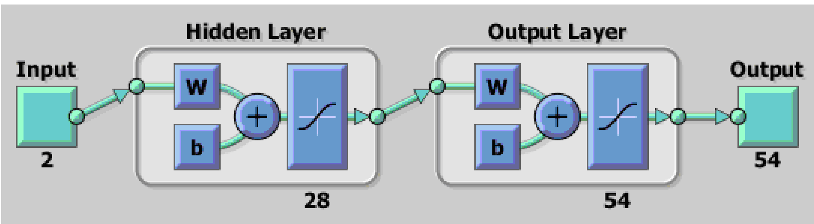

Figure 1: The structure of the neural network.

The array of input data is a matrix that contains assessments of quality indicators according to the criteria for evaluating the curriculum and educational activities – presented by students and graduates. Network type is feed-forward with back propagation. At the next stage, training and coaching of the network were carried out. After the training ended, the Neural Network / Data Manager window received two types of data: Output Data (O) and Error Data (E). By clicking the Export button in the manager window and then clicking Export again in the window, you can transfer the received data to the MATLAB workspace, where it will be presented in a presentable form.

You can calculate that the average network error is 0.0321, which indicates the efficiency of the system.

After learning the network, you can proceed to data forecasting. Returning to the Network

Table 2
Output signals (O).

Indicators of quality criteria	Student grades								
	1	2	3	4	5	6	7	...	54
1	3.1985	3.252	3.3058	3.3541	3.3933	3.4235	3.4475	…	3.9704
2	3.4521	3.3478	3.2644	3.2035	3.1633	3.1404	3.1319	…	3.9997
3	3.1516	3.1812	3.219	3.2627	3.3062	3.3417	3.3638	…	3.9992
…	…	…	…	…	…	…	…	…	…
54	4	3.4192	3.3522	3.3128	3.291	3.2798	3.2756	…	3.9716

Table 3
Errors (E).

Indicators of quality criteria	Student grades								
	1	2	3	4	5	6	7	...	54
1	-0.199	0.748	-0.306	-0.354	0.607	-0.424	0.552	…	0.0000237
2	0.548	-0.348	-0.264	-0.203	0.837	-0.140	-0.132	…	0.029607
3	-0.152	-0.181	0.781	-0.263	0.694	0.658	-0.364	…	0.00027
…	…	…	…	…	…	…	…	…	…
54	0.58076	-0.3522	-0.3128	-0.2909	0.7202	-0.2755	-0.2769	…	0.028442

Table 4
Neural network forecast and expert evaluation.

Indicators of quality criteria	Forecast	Estimates
1	3.999977	4
2	3.974844	4
3	3.999750	4
4	3.999379	3
5	3.956661	4
6	3.991731	4
7	3.985698	4
…	…	…
54	3.970182	4

and Data Manager window (Neural Network / Data Manager), you need to create additional input by clicking the New button. Going to the Data tab, the name of the data changes, for example, to P1, and the values are set as follows: values 1-54 still indicate the numbers of indicators of quality criteria of the educational program and educational activities, and 56-109 evaluations of students and graduates quality, and the last column – the projected estimates of experts.

Comparing the data issued by the system and the real data, we can see that the neural network does make predictions that are quite close to reality. Compared with expert estimates, the average absolute error is 0.0321, the relative error is 7.08%.

3. Discussion

The study aimed to demonstrate the possibility of predicting the assessment of the quality of educational programs and educational activities can be adequately addressed through an artificial neural network and obtain a comprehensive assessment of the quality of educational programs and educational activities based on a possible neuro-fuzzy approach. The mathematical model involves the use of neural networks and is based on the technology of analytical processing of statistical data. Standard methods of mathematical statistics are used to analyze the estimates received from respondents.

The assumption that based on a sample of students and graduates of higher education the quality of the educational program and educational activities can prepare a sample for setting up and teaching artificial neural networks is confirmed by ordering the quality of the curriculum of students and graduates. teaching. In practice, this allows you to predict the results and identify existing shortcomings and eliminate them before the accreditation examination. However, the difficulty of this method is to choose the architecture of the neural network and prepare a training sample to configure the neural network. In particular, in the future, it is planned to increase the volume of the input vector of the artificial neural network, and the form is based on estimates of teachers, stakeholders, and experts.

4. Conclusions

As a result of a mathematical model of a comprehensive evaluation of the quality of educational programs and educational activities based on the methods of neuro-fuzzy approach, first managed to work out a mechanism for obtaining a quantitative evaluation of educational programs and educational activities in this program that will allow the institution of higher education detect shortcomings and potential problems and solve them before the accreditation examination. Secondly, based on a sample of students and graduates of higher education to evaluate the quality of educational programs and educational activities, you can prepare a training sample for setting up and learning an artificial neural network that can adequately perform a comprehensive assessment of educational programs and educational activities. This can be done by arranging the assessments of the quality of the curriculum and the educational activities of students and graduates in ascending order based on the determination of the average grade point average. It is emphasized that these methods are effective provided they meet the requirements of a student-centered approach and the principles of academic freedom.

Based on a sample of students and graduates of higher education, the quality of the educational program and educational activities was prepared to prepare a training sample for setting up and teaching artificial neural network, which was able to adequately perform a comprehensive assessment of the quality of educational programs and educational activities. A comparison of the results of the operation of an artificial neural network of direct propagation with one output and several inputs with real data shows that the neural network does make predictions close to reality. Compared with expert estimates, the average absolute error was 0.0321; the relative error was 7.08%.

The results of the study can be used in the practice of higher education institutions to predict the results and identify existing shortcomings and eliminate them before the accreditation examination.

We see prospects for further research in the application of software products based on the theory of neural networks to automate the processes of the organization, control, and analysis of the educational process; introduction of neural network software for direct training of students in certain disciplines.

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