Model of the Applicability of Expert System Based on Neural Networks Technology and Hybrid Systems for Decision Making

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Abstract In this chapter it was justified mathematical model of construction of expert systems and methods of its application in educational process. It is given the mathematical formulation of a number of tasks of application of neural networks and hybrid expert systems in the subsystem of decision-making and evaluation of knowledge. By using of fuzzy logic an original method for controlling the student's knowledge was developed which as maximal closely simulating the behavior of the teacher in the student survey, which combines the power and laconism that was not previously available for automated systems. The proposed method of mathematical processing and designing of educational materials on the basis of linguistic variables allows the designer to simulate any configuration of educational materials is an important step in achieving individual learning.

1 Introduction

Nowadays, there are computer-based training systems, which in one or other form include the individual components of expert systems [1, 2]. In most cases these technologies are used as search methods that would give close correlation with maximum rating issued by teacher and accordingly associated with the improvement of block processing and determination of a grade by the test results, and that they did not disclose the full potential of expert systems.

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The modern software and technical solutions have reached a level of development that can solve the problem of high levels of complexity and create a system, using as a base element of designs of low and medium complexity. The principle of modeling in application to automation of the learning process can be described as a set of simple elements, each of them by performing certain terms of responsibilities in the final system and combined with other elements creates a functionally much more complex environment, which can be called intellectual [3].

One of the developed model of expert systems should be ability to simulate the behavior of the teacher in the learning and knowledge evaluation based on fuzzy + neural + hybrid = expert systems [4].

In addition, the student is also a highly intelligent element of the system, and his analysis and reaction to his behavior should also be carefully considered.

In this chapter is suggested a methodology of designing of the components of an expert system as a set of technologies which are most applicable in tasks of complex nonlinear processes, that can develop on the basis of its intellectual environment for educational purposes.

2 Designing of the Learning Environment Which Provides Control of the Educational Process

One of the main given in this chapter problems are a designing of the learning environment which is absolutely able to function with minimal teacher participation and still provide adequate control of the educational process.

In our case, the overall structure of the expert system includes four main elements: the block of decision-making, knowledge base, database and interface to the external environment.

Decision-making block (DMB) is the core of giving to intelligence of the system. The principles of the functioning of DMB provide applicability of the system as a whole in the given task. All other elements are considered as supporting role.

The *knowledge base* contains the functions controlling by reaction of DMB in the emerging development process of events and represent itself an algorithmic model of decision-making by experts for this area of knowledge. The functions controlling by reaction algorithmizated in the form of fuzzy rules, which are relatively easy to be edited to match the specifics of application. The logistics of information flows DMB is largely depends on the functions reactions to events [5].

The database is a repository of information in any format related to this topic at the moment.

User's interface—this is the method of interaction between the user and the system. In high-power systems, the user is provided an opportunity to ask questions and get answers in ordinary language, but the development of such a system is quite a complicated task, it is easier to create a system in which the questions and answers selected within a given list.

The knowledge base contains famous facts expressed in the form of objects and conditions. In addition to the descriptive representations of reality, it involves the expression of uncertainty—limitations on the accuracy of the facts. In this respect it differs from the traditional database because of his character, not numeric and alphanumeric content. Pre-defined logical rules are used while processing of information of the database [6]. Accordingly, the knowledge base, which represents a higher level of abstraction, which deals with classes of objects are not the objects themselves.

The central component of an expert system is the mechanism that searches in the knowledge base on the rules of rational logic for obtaining solutions [7]. This component is activated by receiving a user request and performs the following tasks:

- compares the information contained in the user's request with the information the knowledge base;
- searches for certain goal or causal connection;
- evaluates the relative certainty of factors based on the relevant factors of trust associated with each factor.

The next component of an expert system is the level of trust. Facts are coming to the knowledge base. The connection between the facts presented by heuristic rules—expressions of declarative knowledge about the connection between objects. Each such rule has a component of the "IF" (background) and a component of "THEN" (the conclusion) that defines the forward and reverse causal relationship [8]. Let us consider the example.

Fact: "If a student has solved all the problems, he will get excellent."
Preconditions: "If a student was excellent, he solved all problems."

The actual approval only probable that means that the degree of certainty is not always absolute. Such statements relative certainty is often based on statistics, probability, or simply subjective preconditions. The common scale and the scale used in Intelligent Information System of Learning and Control Knowledge (IISLCK) range from 0 to 100—the higher the degree of the level of trust [9].

Let us divide the generalized problem of a number of subtasks.

The presentation of the facts in the knowledge base. The knowledge base consists of facts and rules. Facts describe what is known about the domain at the moment.

Rules establish situational, conceptual, causal, or precedent relationship between these facts. We represent the facts, identifying objects by describing their attributes and giving those values or equivalents. The word "object" is meant as a physical object (such as "evaluation", or "number of visits"), and general perceptions ("good" or "high achiever").

The attributes associated with objects that activate objects in the system (for example, "failing grade", "absenteeism"). To organize the expression of facts, we combine them into a pair of "object—the value" by combining object name with the name of the attribute.

The chain lists are using to represent objects in the knowledge base. Each item of this list is called a node and contains fields where information about the object is added. One of the fields serves as a pointer to inform the system where to find the next node in the list. Moreover, each node in the object list has a pointer to a list of values associated with the name of the object.

The coefficient of determination. Thus not all knowledge is strictly defined, the expert system must have methods of processing different degrees of confidence in expression of the given facts, moreover, if such subjective allegations tend to absoluteness.

Rules of expert system. The expert system processes the symbolic representation of reality using heuristic rules and the method of inverse chain. In this method the consultation begins with certain purpose or final result [10].

This approach is the opposite of the method of a direct of the chain, where the argument begins with the definition of the problem. A rule consists of two parts: the preconditions and the conclusion. Both precondition and conclusion are the facts of the knowledge base, expressed in pairs "object - the value". In our system, the rules have the following format [11]:

IF PRECONDITION, THEN CONCLUSION

The meaning of this format is that if the precondition is true, then the conclusion is true. These simple connection of "IF-THEN" represents the nodes on which the inference engine is moving toward the goal. The rule may include a Boolean operator "AND" for the formation for more complex expressions.

Searching solutions—the solver. The knowledge base is a description of the subject area of expert system. Solver is an interpreter of the rules, which uses the facts of this knowledge base for solving the problems. It is accomplished by formulating testing hypotheses, and test them for compliance with the stated purpose. The operator sets the goal of counseling in the form of the object name. The solver uses a set of rules, trying to get the value of the specified target object. The system continues to search for as long as one of the suggested solutions would not be correct.

Statement of the ultimate goals. First of all, the distance needed to be determined, the ultimate goal—what is the result to be achieved, when the expert system will solve the problem. The goal should express an action or event that shows the impact of expert systems on the general course of events. At this level of description the degree of uncertainty can be quite large [12].

Definition of interim targets. For the ultimate goal of each system can have a number of sub-goals—actions or specific problems. There are goals that result in achievement of the ultimate goals. At this level, the purpose can also be expressed as an action or event, but the uncertainty is going to decline. When interim goals are defined, the problem is divided into the sub problems. Each goal is the intended result and proposed program for solving individual problem. In addition to setting the desired results solve the problem, the interim goal serves another important function, because of their specific problem—it may require for their individual solutions or isolated systems of knowledge [13].

Identification of problems. Once the professionals (teachers) identified goals of the expert system by knowledge, types of problems to be solved and the method of approaches of system to their solution become obvious.

Extraction of knowledge. After determining the goals and tasks of the system, team of developers is faced with the problem of efficient extraction of expert knowledge. The most obvious method is a simple survey. The interviewed experts and gaining knowledge from handbooks—this is a direct way, but would take too much time. The use of analogies or models can significantly reduce this work. Here is one of option: to collect file expert solutions related to the problems in the subject area, and then analyze the main rules, which are based on these expert solutions. The third source of information is the direct observation or experimentation. The classic way to extract expert knowledge is going through all the stages of the expertizing process by watching expert's (teacher) behavior in a particular case.

The quality of teaching system depends on the exact definition of the characteristics of the student by several key factors: the results of the current material, mastering the previous material, current moral and psychological state of the student.

The problem of selecting further action is solved by the expert system based on these indicators. This may be a continuation of the teaching of new material, the question of the previous passed questions or completion of training.

Electronic catalog of tested student stores all data according to his ability, passing the test schedule, etc. In addition, the folder also stores personal data of the student.

In the process of working with the program the student can only not to test his knowledge, but also learn. This is achieved not only by the way the question is asked, but also by the presence of all of the questions and comments explanations given by the teacher. Access to the Internet will allow the student looking for information anywhere in the world, in the best libraries, archives, search engines, etc.

By achieving sustainable results in matters of a certain group, student can go to the next level of difficulty of the questions. This transition will allow student not to stop at the results achieved, but also develop further.

The stepping in training gives the necessary time to full mastering and strengthening of the material, and then the transition to a new, more difficult material. Each transition is accompanied by a small test on the previous material with an analysis of its mastering.

To this date, the work has been done on learning and testing services of a group of students at the same time. The shared folders are created on a particular subject or subjects leaded by teacher. With these shared folders a teacher can give tasks and exercises to a group of students, as well as check their solutions and results. The structure of shared folders to simplify the work with groups of students and teacher's access to the working directory of students allows the teacher to deal individually with each student. The same thing happens when recommending re-passing the course, and in a more detailed analysis of errors than it was done in shared directories, etc. The complex of IISLCK allows the teacher to add and edit her material, make corrections according to the latest achievements of science and culture [14].

3 The Functional Design of the Systems of Control Knowledge

One of the perspective ways to improve the functioning of the control systems of technical control of knowledge is the application of complex intelligent computer technologies, in particular, systems based on the diverse of knowledge of hybrid expert systems (ES). In hybrid ES represent different kinds of knowledge as conceptual, expert, factual and relevant different methods of its processing.

The main task in the development of hybrid systems is in the best way to combine different forms of representation and processing methods of knowledge in the processing in decision-making of ES, it means, that actual problem is to investigate the possibilities of optimal connection of different mechanisms of knowledge processing to improve the quality, mobility and efficiency of ES in solving problems and knowledge control in conditions of uncertainty.

The mobility of ES is due to the mobility of knowledge base (KB) and its ability to replenish from different information components (database, bases of expert knowledge (BEK), the base of conceptual knowledge (BCK), dynamic files, etc.), as well as various procedures of conclusion. The concretization of knowledge processing in solving problems decomposes them into accurate and inaccurate, complete and incomplete, static and dynamic, single-valued and multi-valued, etc. In addition, the expert knowledge is inaccurate due to their subjective character. The approximation and multiple meanings of knowledge processing leads to the fact that the ES has a deal not with one, but with several alternative areas. Therefore, the incompleteness of knowledge processing can be used not one, but several sources of knowledge.

The application of fuzzy logic hybrid ES of control knowledge may have at least three implementations:

(1) processing of fuzzy vagueness utterances experts, i.e. when the precondition is fuzzy variables, inference machine—mechanism of extract data thereof;
(2) using matrix of fuzzy connections, determining a number of factors and a lot of preconditions. The matrix contains the fuzzy variables relations, a measure which is represented as a real number [0, 1], and determines the cause of the condition, the transformation is a matrix and factors to a form equations of fuzzy relations, and then the resulting system was solved by the composition of the minimum-maximum;
(3) using of fuzzy conclusions. This approach is most often used in the construction of fuzzy knowledge bases [15].

The application of fuzzy hybrid ES to solve problems and control parameters of knowledge processing extends the capabilities this class of intelligent systems, increasing their flexibility and mobility, allows under equal computational resources of computers to conduct expert evaluation more number of variants, increasing the credibility and accuracy of the evaluation of the results.

In this chapter main principles of construction of neuro-fuzzy hybrid ES is considered with diverse knowledge and analysis of its functioning in conditions of uncertainty of parameters control object (of knowledge processing) with the application as a dynamic knowledge base combined models of neural networks (NN) [16].

In a hybrid neuro-fuzzy ES etalon model (EM) is stored in the knowledge base of knowledge processing form refined in the process of acquiring new knowledge. The real model is formed in a database environment, and communication with the EM via the user's requests. Solving the problem of the designing an intelligent system control quality knowledge processing-based on hybrid ES was produced with taking into account the characteristics of the environment of ES.

Hybrid ES consists of the following parts: a database that stores etalon and factual evidence about the process, the results of their comparison, conceptual, physical and info logical models, knowledge base (KB): static (knowledge is stored in the form of expert knowledge (of products)) as well as formulas, facts, dependency, tables, concepts specific subject area); dynamic (the knowledge is stored combined models of NN in the form of etalon of dynamic processes taking into account the partial or complete uncertainly parameter of control), mechanism of logic inference is based on an algorithm for generating cause and effect network of events functional—structural model; adaptation mechanism to coordinate the work of the database (DB) and KB in the process of logical inference depending on the situation, explaining the mechanism, which is an interpretation of the process of logical inference, planner, coordinating the process of solving the problem; solver for finding effective solutions to positive, negative and mixed statements of problems.

The content, form and algorithms of presentation information of hybrid ES have the possibility of varying depending on the complexity of being modeled situation, the specific and individual characteristics of the user.

This user-expert presents the expert in the knowledge in the form of sets of examples. The internal form of presentation of expert knowledge is a derivation tree. A set of examples is described by attributes and provides examples of the same structure, as defined by its attributes, which can be linked by logical transitions. In this case, the relevant trees of inference are combined in such a way that at the terminal vertex of one tree adds another tree.

Computational Model of ES and DB in solving problems under uncertainty is given in summary form:

$$W = \langle A, D, B, F, H \rangle, \tag{1}$$

where A—the set of attributes DB and KB; D—domains (attribute values of DB and KB); B—a set of functional dependencies defined over the attributes;

F—many descriptions of all types used in the B functional dependencies; H—set of fuzzy relations over a set of attributes A.

The following should considered: in each hybrid ES its defined requirements for the form of knowledge representation, and since they are different (frames, semantic networks, databases, the concepts presents in KB of ES, neural networks, fuzzy logic, genetic algorithms), that, even within a single information space in the hybrid ES, combine different knowledge is difficult. For example, in the hybrid ES diverse knowledge is stored static ES and dynamic knowledge on the state of knowledge by neural networks [17].

The modern information and computer technology (based on the approach OLE-technology) can easily share diverse knowledge within a single information space of a hybrid neuro-fuzzy ES.

It should be noted that the considered approach in the work to the creation of the intelligent systems of control and knowledge in a base of hybrid ES functioning in conditions of uncertainty allows:

- apply actively the diverse knowledge (conceptual, structural, procedural, factual, the rule base with the functions of accessories, rules and fuzzy rules DB, KB, BEK, procedures) with a combination of inference mechanisms for effective solution the problem of determining the student's knowledge;
- summarize and improve the conceptual model of representation of diverse knowledge among relational DB and the managed DBMS and interacting with the core of hybrid ES;
- solve effectively the problem of optimizing and the distribution information streams by individual subsystems ES with diverse knowledge conditions of uncertainty.

The methodology of constructing of diverse knowledge of hybrid neuro-fuzzy ES for the control the student's knowledge presents in conditions of uncertainty includes the following stages:

- The formalization of the domain (the development of a conceptual model).
- The description of knowledge model as individual concepts (knowledge) in KB.
- The formation of KB with the rule base as a managing components of intellectual core
- The description of diverse information to control the student's knowledge in the individual sub-systems of hybrid ES (DB, KB, EKB, a graphical DB the calculated files).
- Selecting the model NN and learning rules.
- Development of a program of fuzzy logic.
- Distribution of information streams between the ES and its individual subsystems.
- Testing of individual subsystems of ES with diverse knowledge
- Testing of hybrid neuro-fuzzy ES.

4 Developing the Mathematical Model of the Educational Process

The mechanism of knowledge and ways of its improvement, have a special meaning, and it is one of the most important modules of the training system, for example, on its base model developed for the full cycle of learning with minimal, or no participation of the teacher. In this case the academic year loses its special importance, since education is absolutely individual, i.e., depending on the student's abilities and efforts aimed at obtaining and the assimilation of knowledge, academic year may continue for 2–3 months and for 2–3 years.

To construct a qualitatively new system of organizing the educational process necessary to solve a number problems to improve the intelligence of especially important modules, such as educational material, construction decision-making block, creation knowledge base, implementation of control systems knowledge [18].

Before developing the mathematical model of the educational process was to select a mathematical tool, based on which will algorithmization all future system. The main requirements were the power, flexibility and simplicity for solving problems containing a large number of uncertain variables. Another component of the problem is the need for constant readiness to modify and improve the kernel of system [19].

All these requirements are answered the mathematical apparatus of fuzzy sets. Due to this, as key elements of knowledge base were used fuzzy rules in the form of easy to algorithmizated logical structures [20]:

$$\begin{array}{c} IF\,\mu_A(x_1)THEN\,\mu_B(y_1) \\ IF\,\mu_A(x_2)THEN\,\mu_B(y_2) \\ \ldots \\ IF\,\mu_A(x_n)THEN\,\mu_B(y_m) \end{array} \tag{2}$$

where $\mu_A()$—selection function of the fuzzy rules according to the incoming signal fuzzy x, $\mu_B()$—the function of selection of the reaction system according fuzzy conclusion y. The sets of A and B are the fuzzy space of possible input signals and output reaction of the system: $A = \{a_1, a_2, a_3,\ldots, a_n\}$, $B = \{b_1, b_2, b_3,\ldots, b_m\}$. Figure 1.

These expressions (2), in essence, a template functions for the logical selection corresponding reaction of the decision-making block to the incoming signal generated by a fuzzy learning system to changing external environment [21].

Applicability of the mathematical apparatus of fuzzy logic for use in an uncertain environment of the educational process, supported by opportunities to demonstrate in practice as developments in the field of intellectual challenges, from the set expert systems to models of artificial intelligence.

Creator (Developer) of Fuzzy Logic Professor Lotfi A. Zadeh in his works, recommends the use of linguistic variables for the development of systems that

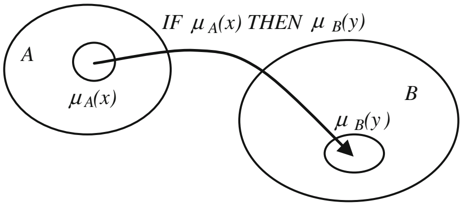

Fig. 1 Method of selection the system reaction $\mu_B(y)$ to receiving an incoming fuzzy signal $\mu_A(x)$

operate with such concepts as human judgments and which are strongly influenced by human factors [22].

Values of linguistic variables are words or phrases of natural language, characterizing the decision taken by a man and feedback reaction to decisions taken by the system.

In the case of the mathematical formalization of the educational process and in particular the object of learning "student", the linguistic variable in the database of student can simply be given as the following linguistic expressions:

$$R_i = \langle M, K, A_Q, R, T \rangle \tag{3}$$

R_i—linguistic suggestion, which characterizes the properties of an object "student" for the special case i as an indicator of knowledge in some a learning course K, educational material M, at response A to a question Q, in which evaluated R, with commentary T.

The advantage of this model, formalizing the characteristics of indicators of students' knowledge, is that every word in your the linguistic variables easy enough to be described almost any situation not provided for in advance, on the occurrence of which can be given by the corresponding reaction decisions making block.

For example, the variable M—describes a set of educational materials, can contain the name of a specific educational material, and the whole field of knowledge.

Thus, when a new discipline (e.g. ekoinformatics) or the merger of several learning courses (e.g. biochemistry, bioinformatics) modification of the fundamental principles of construction system is not required and appropriate educational material to the establishment of new training courses K_{new}, or transferring the existing subsets of the educational materials into a new set of M_{new} (4).

$$M_{new} = \left\{ \begin{matrix} K_{new},\ K_{i1} \in M_k,\ K_{i1} \in M_k, \\ K_{i2} \in M_i,\ K_{i3} \in M_j) \end{matrix} \right\} \tag{4}$$

As seen from Fig. 2, the application of linguistic variables in a semi-structured environments, which is the educational process and the educational system as a whole, a mandatory requirement, otherwise the newly created system of education immediately obsolete, or will have limited applicability [23].

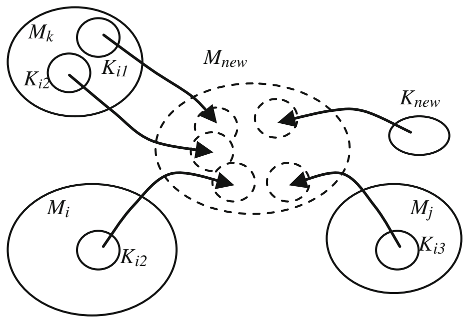

Fig. 2 Model for creating a new value of linguistic variable M_{new}—a new educational material

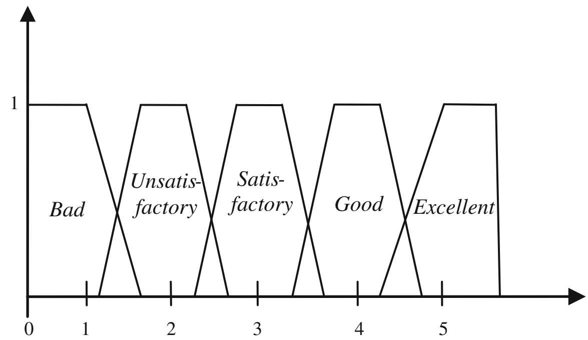

Fig. 3 Membership function of models of the evaluation of the knowledge of student on the basis of linguistic variable with values: it is bad, it is unsatisfactory, it is satisfactory, it is good, excellently

The next problem, which is chosen to match the mathematical apparatus needs improvement is the method evaluation student knowledge. If in the traditional system of evaluations, the student receives a natural number or letter as a characteristic of his knowledge in some area of educational materials, in this chapter, evaluation system is given to a fuzzy form. Figure 3 [24].

On the membership function evaluation “bad” characterized by lack of knowledge, as “excellent”—that the student possesses, the maximum volume of knowledge and skills on the studied materials [25].

Thus, evaluation of knowledge is characterized as a form of uncertainty, since it is not amenable to analysis and measurement with arbitrarily high accuracy.

As in any expert system, the core of the educational system is a knowledge base. Analyzed the existing methods for constructing knowledge bases, the choice was made in favor of fuzzy knowledge base, which provided a strong uncertainty shows a high noise immunity for a fairly simple procedure, modifications and additional study by increasing the base of fuzzy rules.

Classically, in the base of the fuzzy rules stored knowledge and experience of experts, but in an environment of educational purpose is impossible to describe the process of study and knowledge control.

Ways to determine student knowledge, to identify areas with insufficient understanding, defining moment of students’ readiness to transition to the new curriculum is a multifactorial intellectual task. To solve it, a model was created, which handles two types of the systems of states. Each state is served by having the classical form, fuzzy rules [26]:

- Reaction to the situation—is used, for example, during the procedure of control of students' knowledge.

$$\begin{aligned} &IF\ input\ (current\ situation) \\ &\quad Then\ output\ (system\ reaction) \end{aligned} \tag{5}$$

  Has tactical character, for example, decision-making on sample of level of complexity of a following set question, by results of answers to the previous questions.
- Update on the results of learning procedures—used, for example, when updating information on knowledge and misconceptions students, and refinement of the curriculum—individual for each student

$$\begin{aligned} &IF\ input\ (current\ result) \\ &\quad Then\ output\ (database\ update) \end{aligned} \tag{6}$$

Has a strategic character, because, decides on the level of understanding of the relevant section of the course, and should be able to answer the question of whether the transition to the next section learning course [27].

The effectiveness of this model and the quality of processing the input information based on the use of fuzzy rules, and for example, the following fuzzy rules are applied in a block survey of the student.

The criterion for selection next question is the result of the answer to a previous question. The basic formula of the algorithm is described below:

- ……..

1. IF the Answer is correct THEN
2. GeneralWeight +=WeightQuestionI; KategoryQuestion[i] ++;
3. ELSE
4. GeneralWeight1 +=WeightQuestionI; KategoryQuestion1[i] ++;
5. END IF
6. PITCH ++;
7. I = FUZZY (IndexStudent, Subject, Pitch, GeneralWeight, GeneralWeight1, KategoryQuestion, KategoryQuestion1);
8. Transition in a Data Base to I Question
9. Reading, Formatting as a kind of HTML by means of Jscript
10. Expectation of variant of the student's answer
11. Opening the data base of the answers, in order to choose the correct answer
12. Comparison with the student's variant and preservation of an outcome in a variable named Answer
13. Jump to line 1

- ……..

Below are the fuzzy rules applied in the block of the survey of a student—there are two fuzzy rules [9]:

(1) IF the previous question the student answered correctly, THEN in this case, the student is given a more difficult question;
(2) If the previous question the student answered incorrectly, THEN the student is given a simple question.

Mathematically, they can be described by the following formula [28]:

$$V_i = \begin{cases} A_{i-1} \in A_{true} => \mu_{A-}(A_{i-1}, A_{i-2}, \ldots, A_0) \\ A_{i-1} \notin A_{true} => \mu_{A+}(A_{i-1}, A_{i-2}, \ldots, A_0) \end{cases} \quad (7)$$

Where V_i—question, which to be asked the following, A_{true}—set of correct answers, μ_{A-}—function of selection question with the incorrect answer (8), μ_{A+}—function of selection question in correct answer (9), ($A_{i\text{-}1}$, $A_{i\text{-}2}$, …, A_0)—set of answers received for this session of the control of knowledge.

$$\mu_{A-}\left(A_{temp}\right) = V\left(\frac{\begin{cases} \max(A_{temp} \notin A_{true}) \\ A_{\max} \end{cases} + \begin{cases} \min(A_{temp} \in A_{true}) \\ 0 \end{cases}}{2} \pm 2\%\right) \quad (8)$$

$$\mu_{A+}\left(A_{temp}\right) = V\left(\frac{\begin{cases} \max(A_{temp} \in A_{true}) \\ A_{\max} \end{cases} + \begin{cases} \max(A_{temp} \notin A_{true}) \\ A_{\max} \end{cases}}{2} \pm 2\%\right) \quad (9)$$

where A_{temp}—temporary set containing a set of values answers received currently by procedures of control of knowledge $A_{temp} = \{A_{i\text{-}1}, A_{i\text{-}2}, \ldots, A_0\}$, $\begin{cases} \max(A_{temp} \notin A_{true}) \\ A_{\max} \end{cases}$—selection answer with the maximum value from the set A_{temp} does not belong to the set of correct answers, or if no item, value is taken $A_{\max}$—that responds to maximum by a difficulty of the question of knowledge area that perform the procedure control of knowledge, $\begin{cases} \min(A_{temp} \in A_{true}) \\ 0 \end{cases}$—selection answer with a minimum value of the set A_{temp} belonging to the set of correct answers, or if no item is taken value 0—as the minimum possible answer to the easiest question, $\begin{cases} \max(A_{temp} \in A_{true}) \\ A_{\max} \end{cases}$—selection answer with the maximum value from the set A_{temp} belonging to the set of correct answers, or if no item, value is taken $A_{\max}$—that responds to maximum by a difficulty of the question of knowledge area that perform the procedure control of knowledge, ±2 %—is the range within which the selected number of which make an element of chance in selection of by the difficulty of questions, an additional consequence of which is the uniqueness of the lists of questions given to students, even if the order is right and wrong answers to these questions have the same, function $V()$—a procedure for selection of question from the database to by the difficulty as maximum close to the input value [29].

Difference of formulas $\mu_{A-}(A_{temp})$ (8) и $\mu_{A+}(A_{temp})$ (9) is their asymmetry, which is manifested in the fact that, following the correct answer is chosen much more difficult question, and after wrong answer choose question just a little easier. Thus, on one hand the student is motivated by the fact that the show its best knowledge, on the other hand the number of questions to determine the level of student knowledge need to ask a lot less questions than traditional testing.

Applying only these two rules allows qualitatively improve characteristics of control systems knowledge, as it allows to evaluate not only counting the number of correct and incorrect answers, but also provides, by the analysis given in the course of testing questions, the general picture of students' knowledge and the level of understanding, given the educational material.

5 Conclusion

In this chapter proposed the mathematical formulations of some problems of application of neural networks and hybrid expert systems in subsystem of decision-making and evaluation of knowledge.

Using apparatus of fuzzy logic development of an original method for controlling the student's knowledge as closely simulates the behavior of a teacher during the survey a student who combines the power and laconism, not previously accessible to automated systems. Based on improvements in several key aspects of the learning environment, obtained results showing qualitative improvement of quality fixing study materials achieved through the application of algorithm of knowledge control developed on the basis of knowledge mathematical using apparatus of fuzzy logic.

Proposed a fundamental principle of construction of such systems, which can be applied at practically any model of learning. The proposed method of mathematical design and projecting of learning materials based on linguistic variables, allows the developer to simulate any configuration of the learning materials is an important step in achieving individual learning, because now the development of individual student's plan is a technical problem selection of learning courses specific profession, for which the student showed insufficient level knowledge.

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