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Model of Accumulation and Loss of Knowledge in Computerization Systems of Education with Remote Access

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ABSTRACT

The article discusses the approach to the methods of creating expert assessments to determine the level of knowledge of students in education computerization systems with remote access. This is achieved through the use of the probabilistic approach and Bayesian processes in comparison with the approach based on the theory of fuzzy sets. A model for the accumulation and loss of knowledge is proposed. A life-cycle model of a student's knowledge system has been developed. The model of finding the optimal periodicity of the learning process with forced interruptions is investigated.

Key words: Computerization of Education with Remote Access, Fuzzy Sets, Expert Assessment, Bayesian Networks, Knowledge Life Cycle, Knowledge Base.

1. INTRODUCTION

A large number of works are devoted to the problem of choosing the control of learning [1]–[7]. These works are related both to the search for technical teaching aids and modeling of the learning process. One of the tasks in constructing effective diagnostic (expert) systems is the need to take into account a large number of different parameters and their coordination among themselves.

The traditional architecture of the expert system includes a database, a knowledge base and a decision module. The decision module, using the source data from the working memory and knowledge from the knowledge base, forms a sequence of rules that, when applied to the source data, lead to the solution of the problem. The selection and creation of a sequence of rules is one of the main problems in constructing training expert systems. The solution to this problem is directly related to the creation and efficient use of databases from which the source data is taken to select and apply a particular rule [8], [9]. Rules are one or more algorithms that model the process of assessing the knowledge of students in a computerized education system with remote access.

2. MATERIALS AND METHODS

2.1. A brief review of the literature on the research topic

In the study [1], «the problem of representing the properties of complex objects in the knowledge bases of expert systems when they are characterized by uncertainty and there are no ways to evaluate any blur values of their quantitative characteristics ...» is considered. This allowed the authors [1] to establish «acceptable algorithms for identifying the properties of complex objects from fuzzy positions, which can be implemented not only in the case of an expert or systematic setting of the values of a linguistic variable, but also in the absence of them, when the term set is formed on the basis of system procedures».

In the study [2], some sections of the theory of fuzzy sets of type 2 and the theory of fuzzy systems of type 2 are considered operations on fuzzy sets of type 2, fuzzy relations of type 2, the centroid of a fuzzy set of type 2. In [2], a description is also given of functional fuzzy systems of type 2 and relational fuzzy systems of type 2. This makes it possible to use this theoretical approach in education computerization systems with remote access.

In the study [3], the problem of developing mathematical models of patterns of designing requirements for a system is considered. The developed models allow us to formalize the representation of requirements for the system at the level of knowledge. The use of these models can improve the efficiency of IT projects of creating information systems through the reuse of elements developed in previous IT projects.

In [4], an approach to risk analysis was considered, which was developed on the basis of combining interval fuzzy sets, Dempster-Shafer (DS) proof theory and fuzzy Bayesian networks, which act as an approach to supporting systematic decision-making for security insurance throughout the life cycle of a complex system in the face of uncertainty. The proposed risk analysis provides a deep understanding of risk management, especially for complex project environments, thereby reducing the likelihood of failure.

In [5], [10] Bayesian networks with discrete time were proposed as a viable alternative for solving dynamic failure trees without resorting to Markov chains. This approach overcomes the shortcomings of Markov chains. It also benefits from the inherent benefits of Bayesian networks, such as updating probabilities.

The work [5], [11] also showed how dynamic methods can be effectively applied for optimal distribution of security systems, in order to achieve maximum risk reduction.

2.2. The main problems of education computerization systems with remote access

One of the directions of building expert systems is the use of Bayesian trust networks [10], [12], [13]. The use of such an apparatus becomes particularly relevant in connection with the need for an effective search of information in databases.

For example, an important question arises, which method (Bayesian networks or fuzzy sets according to Mamdani) presents less stringent requirements, both for the population of databases and for their search without loss of efficiency.

However, the creation of real expert systems, despite the existing progress in the field of database design, is still fraught with difficulties associated both with the visualization of the results (giving clarity) and with the need to attract qualified developers and experts.

Therefore, the development of a specific training expert system for specific knowledge, it is necessary from the point of view of programming to begin with methods of modeling current knowledge.

In assessing the state of students for making decisions related to the choice of further training tactics, important information is provided by an analysis of subjective knowledge factors.

The complexity of the objective assessment of these factors is the reason for the use of methods focused on building models that take into account the inaccuracy of the source data. It is in such cases that the use of the mathematical apparatus of fuzzy sets (FS) is the most effective [14], [15].

The methods of the theory of fuzzy sets are widely used in various problems of optimization and control. Using fuzzy set theory in these areas is a newer approach.

The theory of fuzzy sets is of great theoretical and practical importance in mathematical modeling of uncertainty. This theory allows us to convey a different kind of uncertainty than probability theory.

Modern study in the field of management in the computerization system of education with remote access reveals difficulties associated with both the lack of live contact with students and the lack of contact with teachers and managers (department employees). Even online communication is not always able to fully replace the live contact between the teacher and the trainee. Currently, there is an active search for a solution to this problem. This problem leads to ambiguity (even inconsistency) in the development of criteria for assessing knowledge, as well as to difficulties in the learning management process, failures.

One of the ways to overcome such difficulties may be the development of methods, recommendations for improving automated systems for managing the learning process, automated systems that facilitate the learning process, automated learning process control systems.

Thus, this area of study is determined by:

1. The lack of correlation between automated training systems automated systems facilitating the learning process and automated learning process control systems.

2. The lack of a module providing for forecasting and the ability to display statistics (statistical assessment of the demand for certain techniques).

3. The lack of the ability to automatically control knowledge in real time.

The latter is especially important, since it is known that for a student who worked uniformly throughout the entire training period, the amount of knowledge changes exponentially with increasing time (much less linearly). If the same (or another with great abilities) did not work evenly throughout the entire training period, and prepared for the control of knowledge in the last month or even worse than 2 weeks, their knowledge could theoretically change in a steeper exponent, but after the control of knowledge decrease in time at a steeper exponent. This fact is especially important in the case of using education with remote access in computerization systems. This fact also makes special demands on the system for assessing residual knowledge, since the fact that a student who has not attended classes with (sufficient) success passing the knowledge control points may show an unsatisfactory result, i.e. much lower than for example «diligent learner». Although both trainees can pass the session equally successfully, or even the trainee «truant» can show better results.

3. RESULTS AND DISCUSSION

3.1. The general concept of the model of dynamics and knowledge accumulation

In the case of using computerized education systems with remote access, it is necessary to take into account the fact that the student is forced to work, and therefore curricula, methods, curricula, teaching materials, etc., developed for in-house training need rethinking and processing for use in the education computerization system with remote access [16]– [19]. Moreover, such a processing of programs should take into account:

- whether his work is connected with a specialty acquired remotely;
- duration of his working day;
- does he work in shifts?
- is his work related to physical labor.

These and similar circumstances are very important, because it is known that the longer the break in the learning process, the more time is needed to restore acquired knowledge. Fig. 1 shows the dynamics of the accumulation of knowledge (left half of the graph) and the loss of knowledge (right half of the graph) if the process of using knowledge does not occur.

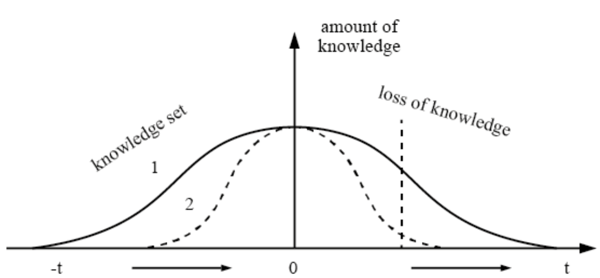

Figure 1: Dynamics of accumulation and loss of knowledge

On the graph, the first learner corresponds to a solid curve, and the second learner corresponds to a dashed curve. As you can see from the graph in the left half shows the process of accumulating knowledge for two different trainees who showed the same level of knowledge at the time of knowledge control. The right side of the graph shows the process of natural loss of knowledge that occurs if knowledge is not renewed. The graph shows that the student who studied only before the control of knowledge (on the graph the second student is indicated by a dashed line), very quickly loses acquired knowledge. This allows you to predict the level of knowledge of students moving on to the next stage.

Consider the model of the life cycle of a student's knowledge system (Fig. 2). Suppose that a trainee accumulates knowledge according to the law of a logistic function. The logistic function finds application in a wide range of fields of knowledge and can be defined by such a formula:

$$y = \frac{1}{1 + e^{-a \cdot x}}.$$

Consider two options: the first option - the student stops studying the discipline, i.e. he begins a net loss of knowledge. The second option, the student continues to accumulate knowledge. This process becomes less intense because, not all the knowledge that has been accumulated is used. Therefore, the mechanism of loss of knowledge comes into play, which inhibits the process of increasing the total amount of knowledge.

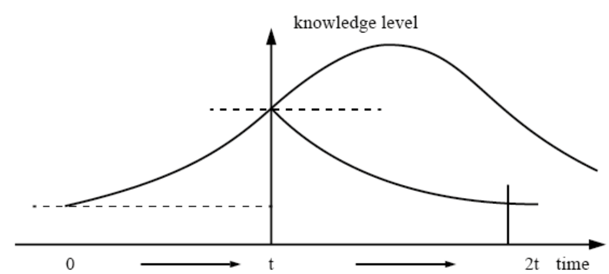

Figure 2: Model of the student's knowledge system life cycle

It is known from practice that a student who works regularly during the training time gains knowledge according to the law of the logistic function. A student with similar abilities, but less attending classes can gain the same amount of knowledge at the time of control. In less time with more intensive independent work, i.e. by the time of control they will gain the same amount of knowledge.

It can be seen from the graph (Fig. 3) that for trainees who, at the time of knowledge control, had accumulated the same amount of knowledge (moment 0 along the time axis t), they would lose knowledge depending on the way of acquiring knowledge.

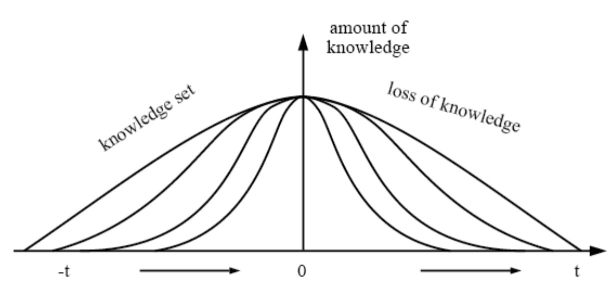

Figure 3: Dependences of the process of loss of knowledge on the method of obtaining knowledge

3.2. Linguistic variables to assess the knowledge of trainees

In the frames of the task of assessing the knowledge of students as linguistic variables, one should use such qualitative indicators as: assessment of attendance (use) of an information resource, assessment of completed tasks individually, assessment of test tasks, evaluation of the result of an interview with a teacher in on-line mode, assessment of course or calculation - graphic tasks. Then this process can have the following formalization.

1. The linguistic variable «assessing the regularity of use of an information resource» is presented as:

<a1,S, X1, G1, M1>,

where:

a1 – use of information resources,
S = {«S daily – daily attendance (B,A), S significant – significant attendance Ex $\neq$ C; S average- average attendance (E); S low – low attendance (Fx)»},
X1 = {0, 30} – the number of terms (elements of the set), for example, the number of downloaded examples (tasks), watched video lessons,
G1 – the procedure for the formation of new terms using logical connectives «AND», «OR» and modifiers like «very», «NOT», «slightly», etc.,
M1 – procedure semantic rules of «correctness», defining membership functions of fuzzy terms generated by syntactic rules G1.

2. The linguistic variable «assessment of completed tasks individually» is presented as:

<a2, К, X2, G2, M2>,

where:

a2 – assessment of completed tasks,
К = {«К excellent -B,A», « К good-C,B» К satisfy.. – Ek, Fx, 0 – misses the correct execution of tasks»},
X2 = {0, 18} – number of terms (elements of the set),
G2 – the procedure for the formation of new terms using logical connectives «AND», «OR» and modifiers such as «very», «NOT», «slightly», etc.,
M2 – procedure semantic rules defining membership functions of fuzzy terms generated by syntactic rules G2.

3. The linguistic variable «assessment of completed test tasks in online mode» is presented as:

<a3, C, X3, G3, M3>,

where: , M3>,

a3 – assessment of completed test tasks online,
T3 = {«C excellent-task done perfectly, C well – task done well, C satisf. – task completed satisfactorily»},
X3 = {0, 20} – number of terms (elements of the set),
G3 – the procedure for the formation of new terms using logical connectives «AND», «OR» and modifiers like «very», «NOT», «slightly», etc.,
M3 – procedure semantic rules defining membership functions of fuzzy terms generated by syntactic rules G3.

4. The linguistic variable «assessment of the result of an interview with a teacher in on-line mode» is presented as:

<a4, T4, X4, G4, M4>,

where:

a4 – degree of knowledge of students during lectures in on-line mode,
C = {«the degree of knowledge is good, the degree of knowledge is average, the degree of knowledge is poor»},
X4 = {0, 10},
G4 – the procedure for the formation of new terms using logical connectives «AND», «OR» and modifiers of the type «very», «NOT», «slightly», etc.,
M4 – a procedure similar to M3 for the rules M4.

The fuzzy knowledge base representing the totality of linguistic utterances has the form:

$$
\mu(a1,a2,a3,S,K,C) = \begin{cases}
Q_{perfectly} \text{ if } ((0<a1 \le S_{daily}) \\
\quad \text{and } (0<a2 \le K_{perfectly}) \\
\quad \text{and } (0<a3 \le C_{perfectly})) \\
\text{or } ((S_{daily} < a1 \le S_{average}) \\
\quad \text{and } (0<a2 \le K_{perfectly}) \\
\quad \text{and } (C_{perfectly} < a3 \le C_{perfectly})) \\
Q_{fine} \text{ if } ((S_{fine} < a1 \le S_{average}) \\
\quad \text{and } (K_{perfectly} < a2 \le K_{fine}) \\
\quad \text{and } (C_{perfectly} < a3 \le C_{fine})) \\
Q_{satisfactorily} \text{ if } ((0<a1 \le S_{daily}) \\
\quad \text{and } (K_{perfectly} < a2 \le K_{fine}) \\
\quad \text{and } (C_{perfectly} < a3 \le C_{fine})) \\
Q_{notsatisfactorily} \text{ if } (S_{daily} (< a1 \le S_{\text{серед}}) \\
\quad \text{and } (K_{satisfactory} < a2 \le K_{fine}) \\
\quad \text{and } (C_{fine} < a3 \le C_{satisfactorily})) \\
\quad \text{or } ((S_{daily} < a1 \le S_{average}) \\
\quad \text{and } (K_{fine} < a2 \le K_{satisfactorily}) \\
\quad \text{and } (C_{fine} < a3 \le C_{satisfactorily})) \\
\quad \text{or } ((S_{average} < a1 \le S_{much}) \\
\quad \text{and } ((K_{fine} < a2 \le K_{satisfactorily})) \\
\quad \text{and } (C_{fine} < a3 \le C_{satisfactorily}))
\end{cases}
$$

There are five variables in this relation, not counting the constants on which the variables S, K, C, G, T are decomposed, which complicates the construction of the membership function in explicit form.

[

3.3. Discussion

Consideration of a generalized model of the life cycle of a student's knowledge system and a model of the dynamics of the accumulation and loss of knowledge allows us to give the most complete structuring of problems in assessing knowledge in computerized systems with remote access. Taking into account the features in the development of programs for students with remote access can reduce the degree of uncertainty in the accumulation of knowledge. This approach is different from the proposed approaches, which are disclosed in the works [1], [3].

Modeling the process of accumulation and loss of knowledge using the logistic function expands and clarifies the possible risks associated with the loss of knowledge and the need to pass control points. Thus, we can assume that the approach is a complement to the approaches considered in the works [4], [5].

The considered set of linguistic variables complements the theory of accumulation and loss of knowledge in education computerization systems with remote access, which is discussed in the study [2].

4. CONCLUSION

A knowledge base model is constructed that is filled with rules to determine the importance of the type of assessment. The proposed model of the accumulation and loss of knowledge allows, according to the individual data of the student, to build an appropriate training schedule that will take into account the need for the renewal of specific portions of knowledge by students.

A model of the student's life cycle has been developed, the proposed life cycle model: the student's knowledge system and the model for finding the optimal frequency of the learning process with forced interruptions allows you to organize a more effective training schedule for the student (recipient).

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