THE METHOD OF FORMALIZATION OF ADAPTIVE LEARNING MODEL BASED ON PRECEDENTS MATRIX

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Abstract - **The technology of forming of adaptive model using the method of precedents is examined in the article. The proposed model allows us to form a self-learning system by allowing incremental expansion of precedents base, which is the basis for the implementation of CAD software.**

Keywords - **adaptive learning, information quantum, precedents method, adaptive model.**

I. INTRODUCTION

The review of known computer systems shows that for the development of models of students' adaptive behavior a variety of means is used: Petri nets, Markov chains, neural networks, graph theory, matrix method.

The presented instrumental means are characterized by organization rather complex and time-consuming learning processes related to the high dimensionality of the tasks, the presence of variables of different types, the requirements to the quality of a result.

The basis of adaptive control of developed system of knowledge transfer is a method of precedents output [1]. The essence of the proposed method is that while teaching a new student the knowledge about situations or cases (precedents) occurred earlier is used. Similar precedents are used as patterns for forming future scenario of the educational process.

Mathematically, this method allows to analyze the functional relationship between the entry and initial parameters of the educational system, resulting in adaptation of the system to the current level of student's training.

II. General formalization of precedents method

For formalization of method successive realization of next informative processes is needed:

1) entry parameters are the array of precedents that is accumulated both due to the modelled cases and cases from practice of educational behavior of students :

$$X_i \to F_1\left[X_i, X_{i-1}, ..., X_{i-j}, ..., X_{i-n}\right] \qquad (1)$$

X_i – separate precedent. This totality forms a so-called "base of precedents".

2) initial parameters are formed on the basis of information from the multiparameter student model that is described:

a) $G_i \to F_2\left[G_1, G_2, ..., G_l\right]$ – characteristics that describe the initial level of student understanding of the course being studied;

b) $P_i \to F_3\left[P_1, P_2, ..., P_k\right]$ – parameters that represent current level of acquired new knowledge.

3) in the case of appearance of an unknown educational situation of student behavior there is a search of similar precedent in the system, that is used as an analogue with the aim of its adaptation to the current case:

$$X_i \equiv X_{i-j} = F_4\begin{bmatrix}1, & j = j+0\\ 0, & j = j+1\end{bmatrix},$$

where 1 – the presence of precedent X_i in the array (1),

0 – the absent of precedent X_i in the array (1),

$j = j+1$ - accordingly the increase of precedents base.

Since a new situation will be worked out, it is brought in the base of precedents with its decision for possible further use.

Thus, general formalization is given by information technology of conveyer fulfillment of functionals:

$$F_{AH} = F_1(t) \Rightarrow F_2(t) \Rightarrow F_3(t) \Rightarrow$$

$$F_4(t)\begin{cases}\left[j = j+0, \quad X_j \neq \left\{X_i, X_{i-1}, ..., X_{i-j}, ..., X_{i-n}\right\}\right].\\ \left[j = j+1, \quad X_j \equiv \left\{X_i, X_{i-1}, ..., X_{i-j}, ..., X_{i-n}\right\}\right]\end{cases}$$

The proposed method of forming of adaptive model in comparison with known analogues differs in the extended functional possibilities of the system due to the fact that in the process of identification of student model, presented by vector corteges, there is incremental expansion of precedents base in the case of absence of coinciding of current vector of student model with vectors describing a separate precedent.

In this case, educational process is possible in one of the modes: studies, pre-studies, re-studies [2], each of that is represented by matrix of precedents that allow you to individualize and differentiate the learning process. It is described by a cortege:

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$$(F_1 - F_4) = \begin{cases} M \in M_1, & (n_1, n_2, ..., n_k) \\ M \in M_2, & (m_1, m_2, ..., m_l) \\ M \in M_3, & (g_1, g_2, ..., g_r) \end{cases},$$

where $n_1, n_2, ..., n_k$ – sequence of educational steps to provide the fulfillment of the mode of studies;

$m_1, m_2, ..., m_l$ – sequence of educational steps to provide the fulfillment of the mode of pre-studies;

$g_1, g_2, ..., g_r$ – accordingly sequence of educational steps to provide the fulfillment of the mode of re-studies;

M_1, M_2, M_3 - accordingly high, medium and low level of student knowledge, that is calculated by the algorithm of evaluation, based on the balanced assessment of T. Roberts [3]:

$$M_j = \frac{\sum_{i \in Q} M_i \cdot C_i}{\sum_{i \in Q} C_i},$$

where M_i – score on a question q_i; C_i – coefficient of complication of a question q_i; Q – the set of all questions.

The described approach allows to integrate knowledge represented in a subject domain in the mechanism of synthesis of decision in relation to possible direction of the continuation of studies. It allows in comparing to the well-known methods substantially to accelerate the study of certain portions of information that affects on the speed of mastering of learning course by a student.

In the work [4] the general structural diagram of learning module control is suggested by the author that compactly recreates the process of acquirement of new knowledge by a student taking into account the most essential components of the system of knowledge transfer: presentation of learning content, verification of knowledge, adaptive module. The feature of this structure is that the adaptive module constantly amends in forming of content of educational information depending on the current results of verification of gain knowledge. As a result, a new portion of educational information (Fig. 1) acts on the entrance of the adaptive program.

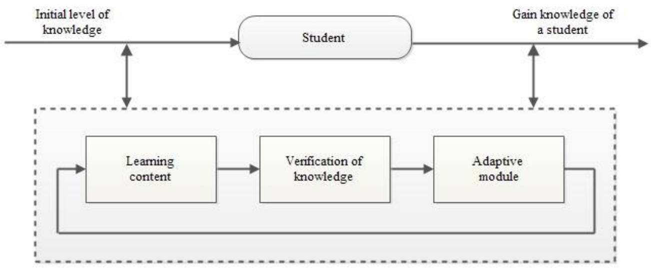

Fig.1. Stuctural diagram of educational process control

III. The forming of time epures of mastering information quanta

For the study of separate quantum information k_i with weight β a student is given a certain interval of time τ. Therefore, depending on duration of the study of quantum information a student can learn in different ways the percentage of informative contents of this quantum that is determined by the function of dependence of the level of mastering a quantum on duration of the study. For example, in Figure 2 a graphical presentation of individual trajectories of the study of the same quantum by three different students is shown:

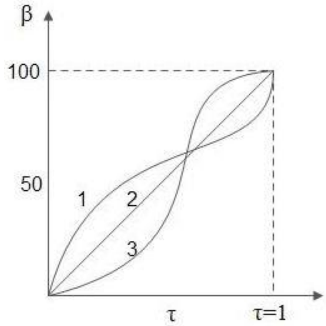

Fig.2. A function of dependence of the study of quantum k_i on time

Generally speaking statistics of mastering of separate portion of knowledge differs for different students. For the further forming of epures of mastering information quanta we will look a partial case: we take into account the function of mastering the knowledge on the interval of one quantum linear (trajectory 2 in fig. 2), which corresponds to average statistics of the study of different quanta and different students.

We systematize the possible cases of mastering knowledge quanta on the basis of time epures [5].

1) Quanta of knowledge are given on the study without a time gap $\Delta\tau = 0$:

a) duration the study of quantum is identical, the degree of mastering quantum is identical (Fig. 3):

$$W_v = \begin{Bmatrix} n = const \\ \tau = const \\ \beta = const = 100\% \\ \Delta\tau = 0 \end{Bmatrix}$$

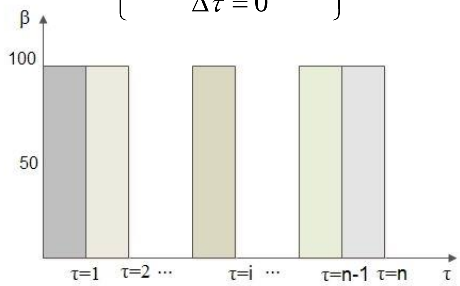

Fig. 3. A structure of epure for the case 1a

b) duration of the study of quantum is different, the degree of mastering quantum is identical (Fig. 4):

$$W_v = \begin{Bmatrix} n = const \\ \tau = \text{var} \\ \beta = const = 100\% \\ \Delta\tau = 0 \end{Bmatrix}$$

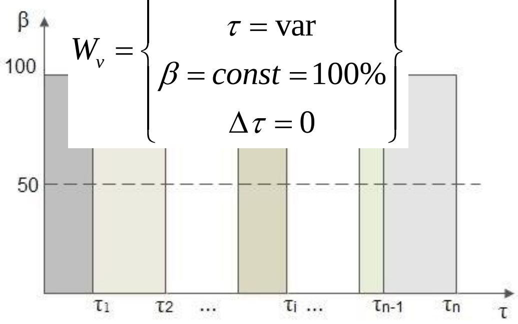

Fig. 4. A structure of epure for the case 1b

c) duration of the study quantum is different, the degree of mastering quantum is different (Fig. 5)

$$W_v = \begin{Bmatrix} n = const \\ \tau = \text{var} \\ \beta = \text{var} \\ \Delta\tau = 0 \end{Bmatrix}$$

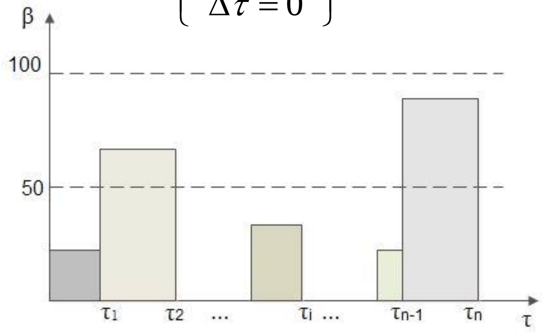

Fig. 5. A structure of epure for the case 1c

The weight coefficient of selective mathematical hope for the described cases when $\Delta\tau = 0$ is calculated in the following expression:

$$M_v = \frac{1}{n}\sum_i^n k_i \beta_i \,, \qquad (2)$$

where k_i – weight of quantum, β_i – actual percentage of mastering a quantum, n – number of quanta.

2) Quanta of knowledge are given for the study with time gap $\Delta\tau \neq 0$:

a) duration of the study of quantum is identical, the degree of mastering quantum is identical (Fig. 6):

$$W_v = \begin{Bmatrix} n = const \\ \tau = const \\ \beta = const = 100\% \\ \Delta\tau \neq 0 \end{Bmatrix}$$

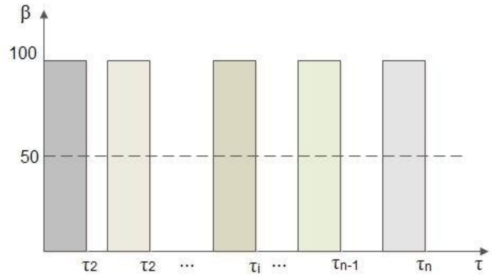

Fig. 6. A structure of epure for the case 2a

b) duration of the study of quantum is different, the degree of mastering quantum is identical (Fig. 7)

$$W_v = \begin{Bmatrix} n = const \\ \tau = \text{var} \\ \beta = const = 100\% \\ \Delta\tau \neq 0 \end{Bmatrix}$$

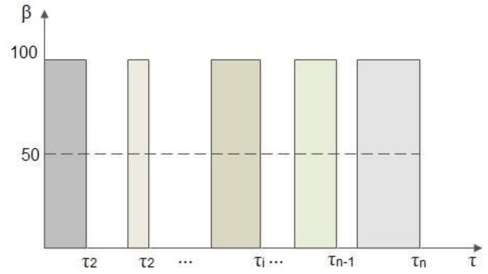

Fig. 7. A structure of epure for the case 2b

c) duration of the study of quantum is different, the degree of mastering quantum is different (Fig. 8)

$$W_v = \begin{Bmatrix} n = const \\ \tau = \text{var} \\ \beta = \text{var} \\ \Delta\tau \neq 0 \end{Bmatrix},$$

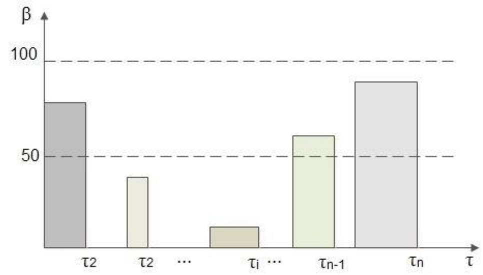

Fig. 8. A structure of epure for the case 2c

The weight coefficient of selective mathematical hope for the described cases when $\Delta\tau \neq 0$ is calculated in the following expression:

$$M_v = \frac{1}{n}\sum_i^n \frac{k_i \beta_i}{\tau_i} \,, \qquad (3)$$

where $\tau_i = \frac{m}{n}$, m – total time of the study, n – number of quanta.

The formed epures give the opportunity to educe totality of quanta that is not mastered in a complete measure, that allows to bring in a correction in educational process by the increase of informative content of these quanta.

In general case the process of studies, representing time-history of the level of student knowledge, is described by linear differential equation:

$$\frac{dM}{dt} = f(t)\,, \qquad (4)$$

where $M = M(t)$ – a level of current knowledge, $f(t) = M_0 + M_p t$ – a function of mastering new knowledge during time t, M_0 – an initial level of knowledge, M_p – a current level of knowledge.

After integration of formula (4) we get:

$$M = M_0 + M_p t. \quad (5)$$

This case corresponds a learning trajectory 2 shown in Fig. 2 that used for the forming of epures of mastering information quanta (Fig. 3 - Fig. 8).

In practice, during realization of the automated training on a certain time interval, the processes of ageing of information occur that is represented by attenuation coefficient α of ex-potential function, which characterizes the degree of forgetting knowledge of a student.

Coefficient α will be minimal if a student constantly revises and consolidates already studied quanta of knowledge and the less will be the time τ ($\Delta\tau \to 0$), that indicates the time gap of the studying between separate quanta (Fig. 3).

We will consider the following simple model. We will assume that knowledge transfer takes place at a constant speed and intensity and characteristics of forgetting knowledge described by linear dependence. In this case, equation (4) becomes:

$$\frac{dM}{dt} = f(t) - \alpha Z . \quad (6)$$

After integration of formula (6) we get:

$$M = M_0 + (M_p - \alpha M_0)t . \quad (7)$$

A graph of dependence of the got level of knowledge M on time t, spent on studies, for the described model is depicted in Fig. 9 (trajectory 2):

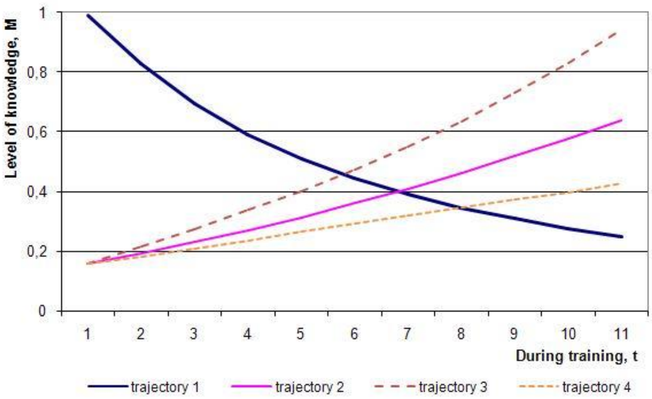

Fig. 9. A graph of depiction of a teacher and a student interaction

The function of adaptive module, which is a component of the general structural diagram of the adaptive system (Fig. 1) is to find an adequate precedent and set a learning trajectory of a student in order to eliminate existent gaps in knowledge.

Depicted in Fig. 9 model-function of adaptive module (trajectory 1) shows how the educational system is in the search of current knowledge of a student (corresponding to the point of intersection of curves) with the aim to adjust the system to his training needs.

If a student improves his skills by mastering of additional quanta of information, then learning trajectory goes up and he gets the opportunity to learn more knowledge from the educational system (trajectory 3), which is depicted on axis of ordinates. Similarly, when a student does not master an appropriate portion of knowledge, there is the effect of ageing of information and decline of level of his knowledge, and accordingly reduction of the intensity of acquirement of new knowledge from the system (trajectory 4).

IV. Conclusion

In the work the formalization of adaptive learning model with the use of precedents approach has been fulfilled. This approach promotes individualized teaching of students in accordance with their current educational success.

The conducted analysis of time diagrams of mastering information quanta clearly explains how the adaptive module for different students and different learning situations performs functions related to getting and processing of the current learning results and the decision-making about further corrections in the organization of educational process.

The developed method is the basis for creating computer software system designed for distance learning and can be successfully applied in educational establishments in conditions of curricular reorganization.

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