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# MATHEMATICAL MODEL OF DISTANCE LEARNING CONTROL SYSTEM IN FRAMEWORK OF IEIT

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## Abstract

The problem of synthesis a mathematical model of machine made control of students knowledge level within information and extreme intellectual technology of analysis and synthesis control systems of the weakly formalized processes, and optimization its functional parameters using information-entropy criterion is considered.

# Introduction and statement of the problem

The process of study is considered as joining of two dynamic procedures, knowledge giving and knowledge taking out. The first procedure is realized by means of transportation of information with using of modern information technologies and does not provoke and complication [1]. The realization of the second one needs the development of the intellectual component of the adaptive system of management by distance learning (S.M.D.L) that is connected with the modeling of the cognitive process of perception of knowledge. Whit that the functional effectiveness of the S.M.D.L considerably depends on the algorithm of student knowledge. Unfortunately the most of the well-known S.M.D.L uses the testing systems which are not mathematically a rugged at the stage of knowledge control. These testing systems as a rule are based on one level additive system of marks and don't allow to reflect the student knowledge objectively [2-5]. In this work [6] the realization of non-linear criterion function of tests on the base of multi strata neuron nets with the aim of the construction of key rules that linearly divide is considered. But with that problem of optimum test generating is not considered. So the problem of optimization of parameters of test generating within the information extreme intellectual technology (IEIT) of synthesis of machine agent "Tutor" which realizes the stage of study is considered in this work.

Consider the problem of a making and optimization of testing parameters within IEIT. Let according to the results of test control a priori classified learning matrix of the tape "object-property"  $|| y_{m,i}^{(j)} | m = \overline{1,M}; i = \overline{1,N}; j = \overline{1,n} ||$ , where M is a number of classes of recognition (of knowledge levels); N is a number of tests according to the material of the line modulus of the distance course; n is a volume of study choice (a number of realization forms). The structured vector of spatial temporal parameters of functions of S.M.D.L.  $g = \langle d_m, x_m, \delta, k_B, k_3 \rangle$  with corresponding limitations, where  $d_m, x_m$  are phenotype parameters that define the geometry of space division of signs info the classes of recognition;  $\delta$  is the genetype of the control admittance field;  $k_B, k_3$  are the genetype didactic parameters of the S.M.D.L. coefficients of validity and significance of tests is formed. We'll estimate the effectiveness of the S.M.D.L. learning with information criterion of function effectiveness (CFE). We'll consider its middle meaning as CFE

$$E^* = \frac{1}{M} \sum_{m=1}^{M} \max_{G} E_n$$

where  $E_m$  is CFE of study of the system to recognize the realization of the class  $X_m^o$ ; G –is field of permissible meaning of parameters S.M.D.L. functioning.

#### Mathematical model of the S.M.D.L.

We'll represent mathematical entrance S.M.D.L. description that optimizes the parameters of test generating as theoretical plural structure:

$$\Delta_B < G, T, \Omega, Z, S, Y, \Phi >$$

where G is a great number of entrance signals (a great number of tests); T is a great number the moments of taking down of data (testing results);  $\Omega$  is the space of signs of recognition (separate answers the questions); Z is a great number functional positions of the system (a level of student knowledge); S is a great number of knowledge marks; Y is a selected great number (a priori classified study matrix);  $\Phi: G \times T \times \Omega \times Z \times S \rightarrow Y$  is an operator of going out which forms study matrix.

We'll show the category model of the S.M.D.L. as a diagram of the reflection of great numbers, which are used in the process of optimization of didactic parameters of test generating.

In the diagram (1) the operator  $\theta: Y \to \widetilde{\mathfrak{R}}^{|M|}$  builds slipshod division  $\widetilde{\mathfrak{R}}^{|M|}$  that in general occasion assumers crossing of recognition classes and the operator  $\Psi: \mathfrak{R}^{|M|} \to I^{|I|}$  checks up the static hypothesis

 $\gamma_1: y_{m,i}^{(j)} \in X_m^o$ , where  $I^{|l|}$  – is a great number hypotheses which for M = 2 and besides the main hypotheses includes the alternative one  $\gamma_2: y_{m,i}^{(j)} \notin X_m^o$ . the operator  $\gamma$  determines a number of exactness characteristics  $\mathfrak{I}^{|q|}$ , where  $q = l^2$ , and the operator  $\varphi$  computers meanings of information criterion of optimization which are the elements of a term great number E.



The operator r corrects within the base algorithm of LEARNING [7] the division  $\widetilde{\mathfrak{R}}^{|M|}$  during the process of optimization of the geometrical parameters of containers of recognition classes that renew in radial basis of discrete space of recognition signs. Besides the contour of the base algorithm of learning the diagram (1) also containers the contours of optimizations of control admittances, where a term number D is the meaning of the systems of control admittances of the didactic parameters of test generating in which  $\omega$  and  $\nu$  are great numbers of meanings of the coefficients of validity  $k_B$  and of significance  $k_3$  accordingly. Here  $\Sigma^{\Lambda}$  is the open succession of tests that is generating. The operator U regulates the process of S.M.D.L. study.

## **Criterion of function effectiveness**

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The working formula of CFE of S.M.D.L. study according to Khulbak (a) looks like [8].

$$E_{m} = \frac{1}{n} \log_{2} \left\{ \frac{2n + 10^{-r} - \left[K_{1}^{(k)} + K_{2}^{(k)}\right]}{\left[K_{1}^{(k)} + K_{2}^{(k)}\right] + 10^{-r}} \right\} * \left[2n - \left(K_{1}^{(k)} + K_{2}^{(k)}\right)\right]$$
(2)

So far as study choice is limited in volume; their marks are considered in practice instead of the mistakes of the first and the second type:  $\alpha^{(k)} = K_1^{(k)} / n$ ,  $\beta = K_2 / n$ , where  $K_1$  is a quantity of realizations of class  $X_1^o$ , which are not in the k- container of this class, that renews on the k-step of study;  $K_2^{(k)}$  is a quantity of "strange" realization which are in the k container of the class  $X_m^o$ . Here  $10^{-r}$  – is any little positive number which allows to avoid appearance of zero in the dominator of the fraction.

Submit for consideration the algorithm of the didactic parameters of test generating within IEIT as an iterative procedure of approaching of global maximum of information CFE of S.M.D.S. study to its limit meaning:

$$k_{3}^{*} = <\arg\max_{G_{1}} \{\max_{G_{2}} \{\max_{G_{3}} \{\max_{G_{4}} \{\max_{G_{5}} E_{m}\}\}\}\} >$$
(3)

where  $G_1, G_2, G_3, G_4, G_5$  are permissible fields of meanings of the parameters of functioning  $k_3, k_B, \delta, x_m, d_m$  correspondingly.

Let's consider optimization of the parameters of test generating taking as an example estimation of student knowledge in subject "Intellectual systems", which is teaching at the department of information science at Sumy State University.

#### Rusults

During the process of realization on the algorithm (3) according the criterion (2) the optimum containers for four classes of recognition were made:  $X_1^o$ -"excellent";  $X_2^o$ -"good";  $X_3^o$ -"satisfactory" and  $X_4^o$ -"unsatisfactory". At the pics 1-4 you can see the results of optimization of the containers of these classes where the hatched section indicates the working (permissible) sphere of definition of function of criterion of optimization (2).

According to the pic. 1 the optimum radius of the hyper spherical container is  $d_1^* = 21$  in code units of Hemming. The analysis of the pic. 2 shows that the radius of the optimum container is  $d_2^* = 20$  in code units of Hemming

Sec.C

with maximum meaning of CFE of the S.M.D.L. study  $E_2^* = 0.55$ .



Fig.1. Dependence of criterion of optimization from the radius of the container the class  $X_1^o$ 



Fig. 3. Dependence of CFE (2) from the radius of the container of the class  $X_3^o$ 



Fig.2. Dependence of criterion of optimization (2) from the radius of the container of the class  $X_2^o$ 



Fig.4. Dependence of CFE (2) from the radius of the container of the class  $X_4^o$ 

The analysis of the pic. 3 shows that the radius of optimum container is  $d_3^* = 17$  of Hemming code units with the meaning of CFE of S.M.D.S. study  $E_3^* = 0.95$ . As it is clear from the pic. 4 during the optimization of the container of the class  $X_4^o$  we have  $d_4^* = 26$  with the correspondent meaning of CFE of S.M.D.S study  $E_4^* = 0.28$ 

So, the possibility of rise of effectiveness on the S.M.D.L functioning by means of optimization of the parameters of test generation and renewing the optimum classifier in information understanding in the process of study is experimentally confirmed.

In the work the problem of synthesis intellectual adaptive control system of e-learning based on optimization of the didactic parameters of test generating of the multiagent S.M.D.L in framework of IEIT, allows to the elaborator of the distance course to define with reason the ponder able coefficients of significance and validity of the lets for machine control of student knowledge is formed and resolved.

The results of physical modeling of the developed algorithm show that for making of the clear division of sign space into the classes of recognition (the level of knowledge) it is necessary to realize within IEIT the other spatial temporal parameters influence the asymptomatic (extreme) exactness characteristics of the study process of the machine agent "Tutor".

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