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DEVELOPMENT OF THE MAIN ALGORITHMOF ADAPTIVE TESTING SYSTEM

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Abstract.

The article discusses the principles of construction and operation of the adaptive testing system. Adaptation of these indicators considers the general methodology of the adaptation process in the intelligent tutoring system. Computer-adaptive testing successively selects questions for the purpose of maximizing the precision of the exam based on what is known about the examinee from previous questions.The major goal is to minimize the number of questions in the adaptive test in order to reach the final level of thestudents' ability by modifying the equation of estimation of the student ability level. The paper describes the algorithm to adapt to the learning situation, based on the laws of the iterative learning. It gives the conceptual description of the principles of formation of adaptive learning module. We consider a general model of the adaptive algorithm and the model of the interaction of its parts.

Keywords. Testing system, adaptive testing, e-learning, algorithm, testing methods, student assessment.

Introduction.

In recent years,different kinds of electronic diagnostic equipment (materials) - computer tests - are increasingly used at different stages of the learning process got. This testing is not only a way to monitor and evaluate the knowledge, but it is also used as a tool for the ongoing study of the educational material, for example, as a complement to the electronic textbook. However, traditional testing, which is realized with the help of standardized tests, is gradually losing its relevance.

It develops and evolves into modern more efficient forms of intelligent adaptive testing. Intelligent forms of diagnostics are based non-traditional theoretical and methodological foundations and other techniques of making and reproducing tests [1]. The modules that implement adaptive algorithms must be included into the system. The main advantage of adaptive testing in comparison with classical forms is its obvious effectiveness [2]. An adaptive test can

diagnose the level of knowledge of the examinee by using smaller number of questions. Computer testing system adapts to a user's level directly in the testing process. Due to its flexible adaptation mechanisms the system can select an item of any difficulty to present to the tester at any given time. When implementing adaptive testing the sequence and the number of control tasks in the test are different for different examinees.

Computerized Adaptive Testing is a type of test developed to increase the efficiency of estimating the examinee's knowledge. This is achieved by adjusting the questions to the examinee based on his previous answers (therefore often referred to as tailored testing) during the test duration. The degree of difficulty of the subsequent question is chosen in a way so that the new question is neither too hard, nor too easy for the examinee. More precisely, a question is chosen for which it is estimated, with a probability of 50% that the examinee would answer correctly. Of course, the first question cannot be selected in this way because at this point nothing is known about the examinee's capabilities (a question of medium difficulty is chosen), but the selection of the second question can be better adapted to each examinee. With every following answered question, the computer is increasingly better able to evaluate examinee's knowledge.

The main advantages of adaptive testing in comparison with the classical forms of testing are [3]:

- the feasibility to evaluate the abilities of a testee more accurately and benefit from time savings;
- in terms of a teacher time is used more efficiently and that is why the impact on the results of additional factors (fatigue, anxiety, carelessness) is reduced;
- direct and immediate feedback between students and teachers.

Despite the above advantages, computer adaptive tests have numerous limitations, and they raise several technical and procedural issues [4, 5]:

1. Computerized adaptive testing are not applicable for all subjects and skills. Most testing systems are based on an item-response theory model, yet item response theory is not applicable to all skills and item types.

2. Hardware limitations may restrict the types of items that can be administered by computer. Items involving detailed art work and graphs or extensive reading passages, for example, may be hard to present.

3. The test administration procedures are different. This may cause problems for some examinees.

4. Examinees are not usually permitted to go back and change answers. A clever examinee could intentionally miss initial questions.

The Testing program would then assume low ability and select a series of easy questions. The examinee could then go back and change the answers, getting them all right. The result could be 100% correct answers which would result in the examinee's estimated ability being the highest ability level.

Main part. The main algorithm of adaptive testing system

For the organization of adaptive testing is necessary to select or develop the following components:

- testing methods;
- evaluation methods;
- methods for checking test results;
- the rules of the testing.

In a conventional test, two matters are considered: the time and the length ofthe test. In an adaptive test, possible termination criteria are:

1. The number of questions posed exceeds the maximum number of questions allowed.

2. The accuracy of the estimation of the learner’s proficiency reaches the desired value.

3. Time limitations: most popular adaptive tests have a time limit. Although time limitation is not necessary in adaptive testing, it can be beneficial. Students who spend too much time on tests may get tired, which can negatively affect the score.

4. No more relevant items in the item bank: when the item bank is small, or questions with a difficulty level suitable for the student do not exist, the test must be terminated.

Having analyzed the approaches to adaptive testing we created the template algorithm which defines the basis of adaptive testing and allows to develop test algorithms different in ways of implementing actions. Patterned adaptive algorithm for testing and classification categories which are used to select the action shown in Figure 1.

The choice of how to implement actions template algorithm performed by the developer of the algorithm depending on the purpose of the test and its modalities. Methods of testing vary in terms of adapting to the individual characteristics and test methods for selecting parameters of the testing process. There are methods of partial and full adaptive testing [6].

Partial adaptive testing suggests that the sequence and the number of tests is variedand depends on individual student level. Test system selects number and difficulty of the tasks and dynamically varies it using specially developed testing scenarios and information about correctness of previous student answers.

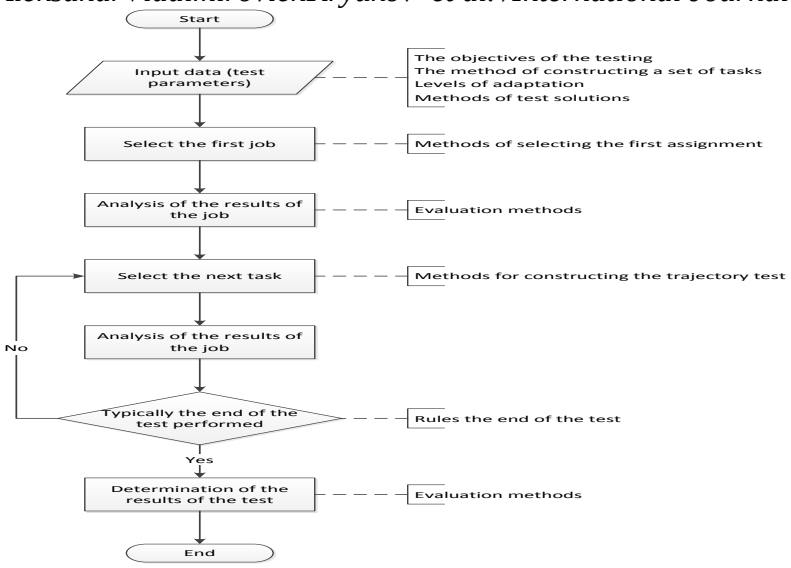

Fig. 1. The template algorithm of the adaptive testing system.

Methods of testing distinguish bytest path construction [7]:

- using the mathematical theory of educational measurement (Item Response Theory, IRT);
- using neural network techniques;
- giving job transitions between states.

Methods of testassessment are used to assess the current and the final test result. In terms of method of calculating assessment evaluation methods are divided into three classes [7]:

- methods based on quantitative criteria;
- methods based on probabilistic criteria;
- methods based on classification criteria.

An algorithmic approach is based on the rules of the form: "if answered correctly, then go to question K1, if the error - K2 question. This method allows you to build a "strict" learning algorithm.

The system provides the possibility of increasing the number of levels in use - for this there is no other fundamental limitations, except in terms of the appropriateness of the destination of the test and the difficulties for the compiler.

The hierarchical structure of the test is shown in Fig. 2.

Consider building a tree survey of the example 1-level testing. For simplicity, we assume the number of test tasks module *t* for testing throughout the study discipline of 2. Given the parameters of evaluation the following principle: when typing the first phase of quiz*t* = 0, the student's knowledge is estimated at a minimum amount of 0 points, and it is excluded from further testing. Upon receipt of the maximum number of points *t* = 2 the student's knowledge is

estimated at a maximum amount of 100 points, and it is also excluded from further testing (each correct answer is worth 50 points).

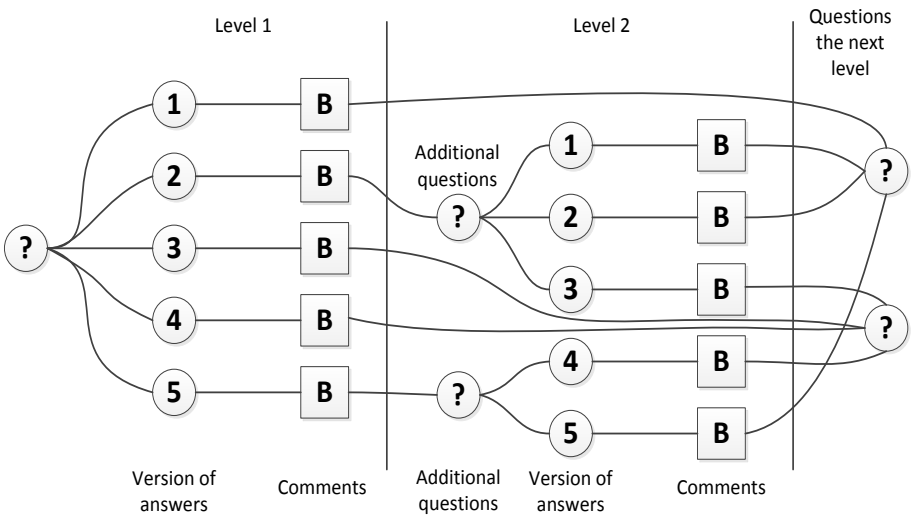

Fig. 2. The structure of the test in the algorithmic approach.

If student gain 1 point in the first phase system should ask clarifying question from the same set. For each correct answer to evaluate student system use the following algorithm:if student provides right answer to the first main phase and right answer in the qualifying phase, then he gets a total amount just under 100 points. Theone-step test algorithm is illustrated bysurvey tree in Fig. 3. Black dots on the diagram shows the tree leaves, indicating the completion of testing, white dots shows intermediate vertices in which testing is not yet complete. Near the leaves indicate the number of correct answers and the total amount of points.

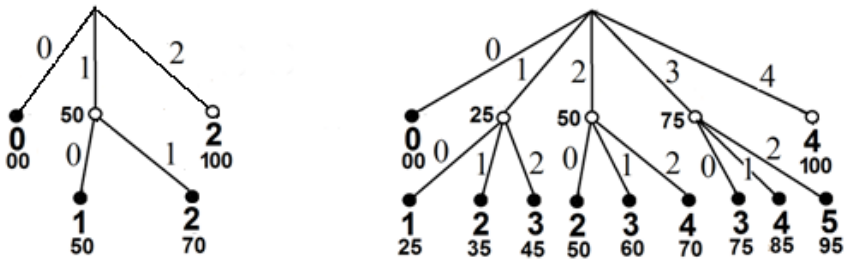

Fig. 3. Driving a single-stage testing algorithm.

To implement an adaptive management approach, we will use the knowledge of the student model, containing information about the current state of knowledge of the student. The proposed model includes the following attributes:

1. <The unique identifier of the student> (*U*) – it is a reference to detailed information about the student.$U=\{U_1, ..., U_k\}$, where*U* – set of learners, *k*– the total number of learners.

2. <Courses> (*C*) –contains a list of student core courses: $C_{ui} = \{C_1,..., C_N\}$, where$C_{ui}$ –set ofcore courses designed for$U_i$student, *N*–the total number of courses.

3. <Modules> (*M*) –contains a list of modules (sections) of the course, where control of knowledge was made: $M_c=\{M_1,...,M_p\}$, whereM_c – modules of the course C_{ui}, P – the total number of modules.

4. <Educational elements> (EE) – list EE, that was passed by a student: $E_{ui}=\{C_1,...,C_F\}$, whereE_{ui} – set ofEE, intended for the passage by$U_i$student, F –total numberof EE.

5. <Current level of achievement> (*L*) – total grade for the course, with values $L \in \{0,1,2,3,4\}$.

6. <Rating> (*r*) – rating from 0 to 1 at the current level of studying, $r \in [0..1]$.

7. <The boundaries of transitions> (*t*) – define the upper and lower boundary of the transition from level to level, for each of the levels (for example, for $L = 1$, assigned that $t_l = 0{,}14$, $t_u = 0{,}86$; this means that at the 1st level of education with $\tau_и$ less than 0,14 student goes to the 0th level; when$\tau_и$more than 0.86, student goes to the 2nd level), $t \in [t_l, t_u]$.

8. <Keyword> (*K*) – a list of keywords related to this module (course), $K = \{K_1,..., K_L\}$.

9. <The unique identifier of the question> (*Q*) – question related to the course and module: $Q = \{Q_1,..., Q_o\}$, where*Q*– set of questions, *O*–the total number of questions.

10. <Type of question> (*T*) – it reflects the type of question. $T \in$ {«Yes»/«No», «Single selection», «Multiple choice», «On conformity», «Open question»}.

11. <Content of the question> – it reflects the content of the question, including text, graphics, multimedia.

12. <Possible answers> – if they are assumed by a type.

13. <Correct answers> (*a*) – in the range from 0% to 100%.

14. <The level of studying> – it shows at what level *L* can be asked.

15. <The complexity of the question>– reflects the difficulty of the question $d \in [0..5]$.

Let's describe a general algorithm for testing.

For each module, question randomly selects, starting from the zero level of studying, with an average level of complexity. If student gives answer on a question of the *i*-th level greater than 75%, level increases by 1 andthe same questions within this module removing. The test continues as long as the student is not able to go to the next level of all modules within current course.

Initial rating on the *i*-th level is determined by the following formula:

$$r = \frac{d}{10} \cdot \frac{a}{100\%}.$$

The level of knowledge has a significant impact on the process of further training[8]. So, if the student has shown a level 3, you should pay particular attention to the ability to apply knowledge in practical problems, to find innovative solutions, creative approach. If the level is zero, you should start learning from the beginning.

The first question is selected from the set of *L*-levelquestions, where level was determined at the input testing.

A new question selects via following algorithm:

- if Δ (the difference in the change of rating) of the last three student's answers did not exceed 0.5, then finish the test;
- if you are exhausted all the questions at this level, then finish the test;
- if you exceeded the maximum number of questions for the test set, then finish the test.

Otherwise, if the correct answer to the previous question is in the range of [75% .. 90%], then selects clarify questionwith the difficulty equal to or close to the previous question.

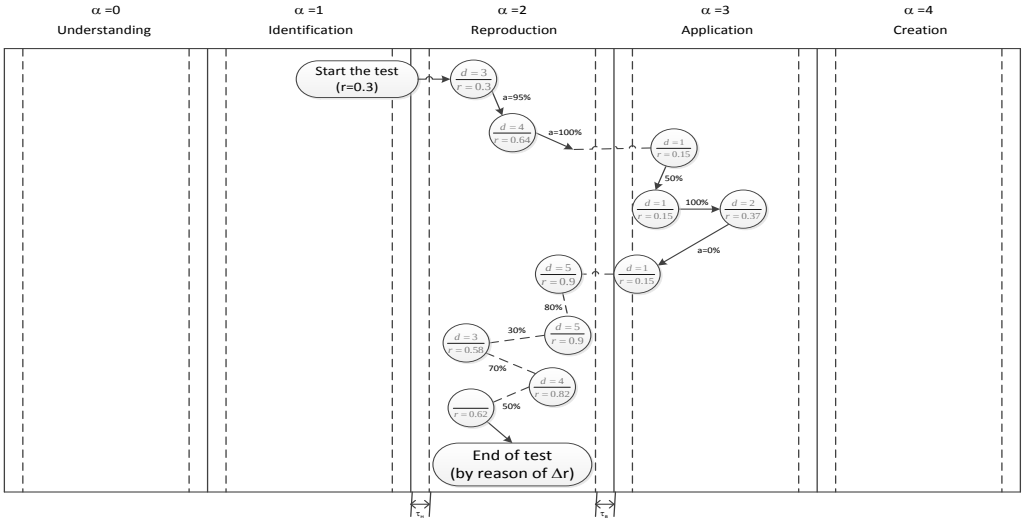

Fig. 4. Example of algorithm to generate questions in the adaptive learning system.

The methods of verification test results vary depending on the order of passing the job in testing. From this point of view, there are two approaches for checking the results of [9]:

- adaptive testing with constant adaptation;
- adaptive testing with block adaptation.

Adaptive testing with constant adaptation implies that the decision to change the order of the tasks performed at each step of testing.

Adaptive testing with a block is a test in which the decision to change the order of the tasks carried out after analyzing the results of the processing of a special task unit.

In computer adaptive testing the following rules the testing can be used [10]:

- the required level of preparation to the test;
- the number of jobs;
- testing time.

The rule based on achieving the required accuracy of measuring a testee's preparation level is mostly used when determining an examinee's preparation level. The limits of preparation level are also used (minimum and maximum). Less often such stop rules as fixed test time and a fixed number of jobs are used.

Summary. The given algorithm allows to evaluate students' knowledge using fewer questions.While the standard approaches make a test-taker answer all the questions of the test. The use of the mechanisms of adaptation to the training module will allow the student to improve the efficiency of the system through the use of more effective methods of teaching.

Conclusions. The examination of different methods of knowledge control, the analysis of the advantages and disadvantages of each approach will allow to develop an algorithm of computerized adaptive testing. The proposed method of adaptive testing algorithms based on the template and the classification of its certain components can be used by developers for testingat educational and vocational institutions.

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