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RESEARCH OF MULTICRITERIAL DECISION-MAKING MODEL FOR EDUCATIONAL INFORMATION SYSTEMS

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Abstract
Subject of Research. Decision-making model is offered for informational and educational systems. The study of multi-criteria model is carried out taking into account knowledge, reaction and doubt. **Method.** The model of material proficiency by the user is based on identification of the personal characteristics when operating with the system. As a result of personal characteristics tracking in the system, an image is formed for each user that can be used for identifying his state: knowledge level, proportion of error, handwriting information, etc. During registration the user is passing an input test. Multi-criteria test results are automatically stored in the user's personal database (agent matrix) and accounted for psychological comfort, formation of the next system content, management of knowledge levels, decision-making when working with the system. The proposed method gives a more clear and "transparent situational picture" for objective decision-making. **Main Results.** Implementation of multi-criteria decision-making model contributes to the quality of distance education. Also, the method makes it possible to reduce the probability of guessing the correct answer, thus increases the objectivity of knowledge level evaluation in diagnostic systems for management of learning process based on remote technologies. **Practical Relevance.** Obtained theoretical results of the work are used in training systems on the basis of multi-criteria decision models. Thus, the proposed model leads to an increase in the average score of about 0.3-0.4 points and reduces the training time in 1.5 to 2.0 times.

Keywords
model, decision-making model, objective assessment, multi-criteria model, level of doubt

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ИССЛЕДОВАНИЕ МУЛЬТИКРИТЕРИАЛЬНОЙ МОДЕЛИ ПРИНЯТИЯ РЕШЕНИЙ ДЛЯ ИНФОРМАЦИОННО-ОБРАЗОВАТЕЛЬНЫХ СИСТЕМ

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Аннотация
Предмет исследования. Предложена модель принятия решений для информационно-образовательных систем. Проведено исследование многокритериальной модели, которая учитывает знание, реакцию, а также сомнение. **Метод.** Модель освоения пользователем материала строится на основе идентификации персональных свойств при работе с системой. В результате отслеживания персональных свойств в системе для каждого пользователя формируется образ, который может использоваться как средство идентификации его состояния: уровень знаний, доля ошибки, информационный почерк и т.д. При регистрации пользователь проходит входное тестирование. Многокритериальные результаты тестирования автоматически сохраняются в персональную базу данных пользователя (матрицу агента) и учитываются для психологического комфорта, формирования следующего контента системы, управления уровнями знаний, принятия решения при работе с системой. Предложенный метод дает более ясную и прозрачную ситуационную картину для объективного принятия решения. **Основной результат.** Внедрение многокритериальной модели принятия решений способствует повышению качества дистанционного образования.

Также метод дает возможность уменьшить вероятность угадывания правильного ответа, что повышает объективность оценки уровня знаний в системах диагностики для управления процессом обучения по дистанционным технологиям. **Практическая ценность.** Полученные теоретические результаты использованы в системах обучения на основе многокритериальной модели принятия решений. Предлагаемая модель приводит к увеличению среднего балла примерно на 0,3–0,4 балла и сокращает время на обучение в полтора – два раза.

Ключевые слова
модель, модель принятия решений, объективное оценивание, многокритериальная модель, уровень сомнения.

Introduction

The aim of the thesis is the development of information and learning system based on multi-criteria decision model for increase of the learning process efficiency and provision of more qualitative e-education services.

Formulated goal required the following tasks: analysis of the existing research and development in the area of design information and training systems; development of multi-criteria decision model for learning management information system; development of new methods and algorithms to assess the level of knowledge; development of structure and architecture of information and training system focused on human-machine interaction; development of information and software training system; implementation of software in educational institutions and checking the effectiveness of information and training system.

Scientific novelties area is the number of new metrics measuring the level of knowledge, in particular, for the first time we have developed the methods for level of doubt measuring in student's knowledge; we have developed and proposed the original model and multi-criteria evaluation method of diagnosing for the student's level of knowledge with the criterion of doubt level by providing more accurate information measurement; we have developed decision rules for training process control system taking into account not only knowledge, but also the levels of response and user confidence; we have designed data logical model information training system based on multi-criteria decision making model; we have designed architecture, software and information support of information and training system based on multi-criteria decision-making model to ensure the effectiveness of the learning process for loan program.

Currently, the requirements for the quality of university students education (qualification level: knowledge, skills, worldview, mind and senses, abilities, personality and character) requires sophisticated testing methods to detect the level of knowledge, taking into account the social and psychological features of the student in order to manage the learning process effectively.

The solution to this problem is possible:

- Firstly, by the integration of all types and methods of testing and validation of knowledge (as well as checking ability, skills and outlook);
- Secondly, by automating the testing process, testing the knowledge and skill level (i.e., quality);
- Thirdly, by achieving maximum objectivity of knowledge evaluation.

Therefore, this paper deals with the latter problem and is focused on maximizing an objective measurement of the level of knowledge. The possibility of solving this problem is to use multi-criterion approach, which measures the number of correct answers given by doubt.

Decision-making model

On the basis of multi-criteria assessment model of knowledge we can identify the main characteristics of the organization and control of automated learning process in information and training system [1]. These include:

- The level of knowledge;
- The level of difficulty;
- The level of reaction;
- The level of confidence [2].

The level of knowledge – the level of current results to the user, based on the coefficient K2 [3].

Difficulty – fixed characteristics prescribed by instructor settings.

The level of response – time assessment of the user's actions in response to any impact. The composition of response level includes coefficients K1, K3 and K5 [4].

The level of confidence – probability characteristic, is inversely proportional to the level of doubt. The structure includes a level of confidence coefficients K4 and K6 [5].

The decision on the basis of multi-criteria model is made in accordance with Figure [6].

Decision-making mode information and training system based on the truth table for the four criteria in accordance with Table 1 [7].

Decision making educational element (action, mode of operation, complexity, time) on the basis of the current state of the educational element is achieved on the basis of the truth table of decision-making in accordance with Table 2 [8].

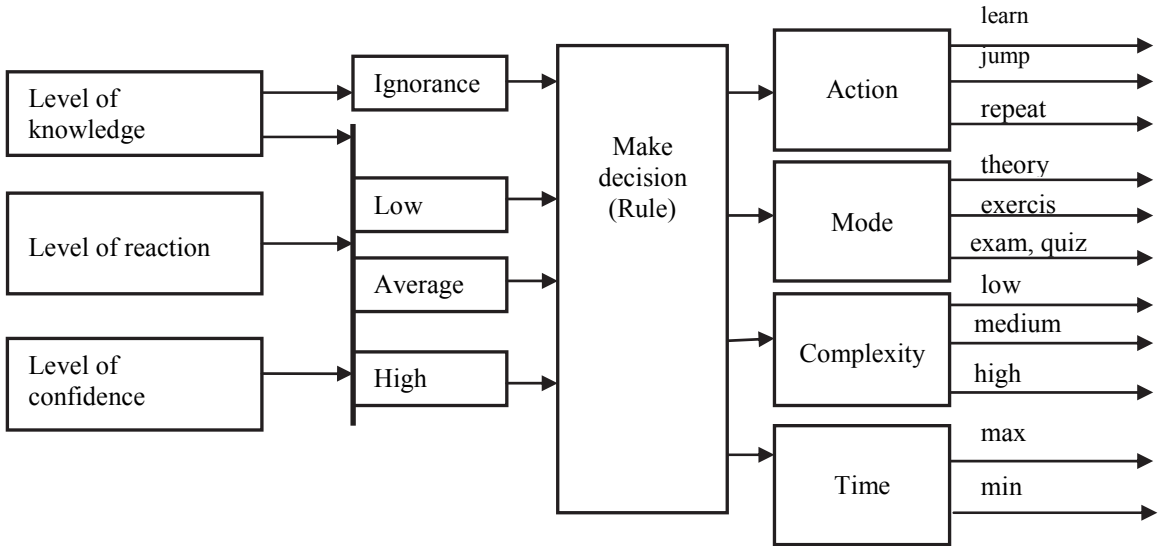

Figure. Multi-criteria decision making model

State				Mode
1	2	3	4	
0	0	0	0	Training (opens. Mode)
0	0	0	1	Training (opens. Mode)
0	0	1	0	Training (opens. Mode)
0	0	1	1	Training (closed Mode)
0	1	0	0	Training (closed Mode)
0	1	0	1	Training (closed Mode)
0	1	1	0	Training (opens. Mode)
0	1	1	1	Training mode
1	0	0	0	Training mode
1	0	0	1	Adaptive mode
1	0	1	0	Adaptive mode
1	0	1	1	Setting a level of education
1	1	0	0	Adaptive mode
1	1	0	1	Coaching mode
1	1	1	0	Correction mode
1	1	1	1	Mode self

Table 1. The truth table of decision-making model on four criteria (1 – max, 0 – min, 1 – knowledge, 2 – level of difficulty, 3 – level of reaction, 4 – level of assurance)

The metric scale of measuring the state of the educational element: ignorance (0–49%) is the first measured by Z0. Low level of knowledge (50–74%) is the second measured by ZA. The average level of knowledge (75–89%) is the third measured by ZB. The high level of knowledge (90–100%) is the fourth measured by ZC. Low level of reaction (0–74%) is the fifth measured by RA. The average level of reaction (75–89%) is the sixth measured by RB. The high level of reaction (90–100%) is the seventh measured by RC. Low level of confidence (0–74%) is the eighth measured by UA. The next is the average level of confidence (75–89%) measured by UB. Then the high level of confidence (90–100%) measured by UC [9].

Complexity has three measures. They are: low complexity measured by A, medium complexity measured by B and high complexity measured by C [10].

State			Decision of EE			
Knowledge	Reaction	Confidence	Complexity	Time	Action	Mode
Z0	RA	UA	A	max	jump	theory
Z0	RA	UB	A	max	learn	theory
Z0	RA	UC	A	max	learn	theory
Z0	RB	UA	A	–	learn	theory
Z0	RB	UB	A	–	learn	theory
Z0	RB	UC	A	–	learn	theory
Z0	RC	UA	A	min	learn	theory
Z0	RC	UB	A	min	learn	theory
Z0	RC	UC	A	min	learn	theory
ZA	RA	UA	A	max	repeat	exercise
ZA	RA	UB	B	max	repeat	–
ZA	RA	UC	B	max	jump	exam, quiz
ZA	RB	UA	A	–	repeat	exercise
ZA	RB	UB	B	–	repeat	–
ZA	RB	UC	B	–	jump	exam, quiz
ZA	RC	UA	A	min	repeat	exercise
ZA	RC	UB	B	min	repeat	–
ZA	RC	UC	B	min	jump	exam, quiz
ZB	RA	UA	A	max	repeat	exercise
ZB	RA	UB	B	max	repeat	–
ZB	RA	UC	C	max	jump	exam, quiz
ZB	RB	UA	A	–	repeat	exercise
ZB	RB	UB	B	–	repeat	–
ZB	RB	UC	C	–	jump	exam, quiz
ZB	RC	UA	A	min	repeat	exercise
ZB	RC	UB	B	min	repeat	–
ZB	RC	UC	C	min	jump	exam, quiz
ZC	RA	UA	B	max	repeat	exercise
ZC	RA	UB	B	max	repeat	–
ZC	RA	UC	C	max	jump	exam, quiz
ZC	RB	UA	B	–	repeat	exercise
ZC	RB	UB	B	–	repeat	–
ZC	RB	UC	C	–	jump	exam, quiz
ZC	RC	UA	B	min	repeat	exercise
ZC	RC	UB	B	min	repeat	–
ZC	RC	UC	C	min	jump	exam, quiz

Table 2. The current state of the educational element and decision

The learning process organization in information-learning system is based on a measure of doubt for control need rules, which formed the knowledge base [11].

Decision-making model generates rules [12]:

```
1:   if (REs knowledge - ignorance and reaction - low, average or high and
     confidence - low,     average or high) THEN (complexity - low, the learning
     mode - the theory, the effect of educational elements - learn);
2:  if (REs knowledge - ignorance, low, average or high and reaction - low and
     confidence - low, average or high), time (time - max);
3:  if (REs knowledge - ignorance, low, average or high and the reaction - high and
     confidence - low, average or high), time (time - min);
4:  if (level of knowledge of UE - low. Medium or high and reaction - low, average
     or high and confidence - high) THEN (action educational element -jump);
5:  if (knowledge UE – low, average or high and reaction - low, average or high and
     confidence - low or average) THEN (action educational element - repeat);
6:  if (knowledge UE – low, average or high and reaction - low, average or high and
     confidence - low) THEN (training mode - exercise);
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7:  if (knowledge UE – low, average or high and reaction - low, average or high and
    confidence - high) THEN (training mode – exam, quiz);
8:  if (knowledge UE - low or average and reaction - low, average or high and
    confidence - Low) THEN (difficulty - Low);
9:  if (knowledge UE - low and reaction - low, average or high and confidence -
    average or high) THEN (difficulty - average);
10: if (the level of knowledge of UE - average and reaction - low, average or high
    and confidence - average) THEN (difficulty - average);
11: if (the level of knowledge of UE - average or high and reaction - low, average
    or high and confidence - high) THEN (complexity - high);
12: if (knowledge UE - high and reaction - low, average or high and confidence -
    low or average) THEN (difficulty - average).
```

Research of multi-criteria decision-making model for educational information systems

Table 3 illustrates input data and decision-making model.

Knowledge	Reaction	Confidence	Mode	Time	Complexity	Ed.element
78	80	70	exercise			repeat
50	70	77			average	
88	90	50	exercise	min	average	
99	49	66	exercise	max		repeat
7	49	44	theory		low	learn
67	66	5	exercise	max		repeat
77	78	44	exercise			repeat
88	90	40	exercise	min	average	
66	98	87		min		repeat
99	58	49	exercise	max		repeat
88	40	50	exercise	max		repeat
40	44	30	theory		low	learn
40	40	88	theory		low	learn
55	55	55	exercise	max		repeat
5	7	8	theory		low	learn
88	95	88		min	high	repeat
4	91	5	theory	min	low	learn
99	6	60	exercise	max		repeat
70	4	6	exercise	max		repeat
60	66	4	exercise	max		repeat
88	85	96	exam,quiz		high	jump

Table 3. Decision-making model

If a student has an Educational element: learn, he/she should learn theory and spend minimum time and complexity must be of low level [13, 14].

For example, the fifth student has characteristics: knowledge is 7%, reaction is 49% and confidence is 44%. The model gives the following results: educational element is “learn”, mode is “theory” and complexity is “low”.

In the database one data exists with the level of knowledge equal to 88%, level of reaction equal to 85% and level of confidence equal to 96%, which has educational element “jump”, mode is “exam” or “quiz” and complexity is high.

That student should pass Exam or Quiz for finishing the course [15].

Conclusion

This paper deals with creation of decision-making model on the basis of measuring the user’s level of doubt to control the learning process. The proposed idea makes it possible to reduce the probability of guessing the correct answer for a more objective assessment of knowledge and adapt the learning process on the basis of the knowledge base.

The results obtained in this study can be used for decision-making in the learning management of information and education distance learning system. The practical value of the work lies in the fact that the use of information in the learning systems based on multi-criteria decision making model obtained in the work leads to increase in the average score on the exam as compared to the control groups by about 0.3-0.4 points and reduce the amount of time required for learning about 1.5–2.0 times.

On the basis of mathematical models and information obtained in the work we have created several computer applications: intelligent information and training system “Programming Languages Borland: Pascal &

Delphi", methodical complex "Mechanics. Molecular physics and thermodynamics", algorithmic learning system "Camel", information learning system for programming "Technology design software based on universal component in Delphi", the interactive test suite of information technology.

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