УДК 62-52
DOI: 10.25559/SITITO.14.201802.472-479

FORMATION OF AN INFORMATION IMAGE OF A GRADUATE OF A MODERN UNIVERSITY USING A FUZZY-GRANULAR APPROACH

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ФОРМИРОВАНИЕ ИНФОРМАЦИОННОГО ОБРАЗА ВЫПУСКНИКА СОВРЕМЕННОГО ВУЗА С ИСПОЛЬЗОВАНИЕМ НЕЧЕТКО-ГРАНУЛИРОВАННОГО ПОДХОДА

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Keywords

Electronic information educational environment; intellectual workplace; logical-linguistic modeling; fuzzy projections.

Abstract

The paper investigates the main problems faced by specialists in the process of selecting of intellectual workplaces (IWP) which are associated with the features of the initial data, inaccurate formulation of the technical specifications for the system, the lack of a single criterion for the effectiveness of IWP. The approach to the formation of IWP in the creation of electronic information and educational environment of the University using the mathematical apparatus of fuzzy sets. On the base of the standard list of characteristics the unified structure of requirements is offered, allowing to consider features of IWP, as an element of the automated training, and features of the solution of tasks of processing of educational and administrative information. The most essential requirements are IWP performance, flexibility, universality, compatibility with control systems and laboratory equipment. When solving the problem of choosing the IWP for processing educational and management information, it is proposed to formalize the generalized requirements in the form of linguistic assessments using the apparatus of the theory of fuzzy sets and use the data structure to represent the parameters and requirements for the IWP. The fuzzy-multiple approach allowing to estimate the formed IWP on the base of the offered structure of requirements is developed. To describe the information space, a combination of logical-linguistic modeling ap-proaches using the apparatus of the general theory of uncertainty and methods of non-factors is proposed. The resulting estimates were aggregated into a final IWP estimate. The proposed simulation allows establishing a fuzzy-multiple relationship between the input parameters of the IWP and its compliance with the proposed system requirements. The results obtained in the work allow forming an information image of a graduate of a modern University using IWP.

Ключевые слова

Электронная информационно-образовательная среда; интеллектуальное рабочее место; логико-лингвистическое моделирование; нечеткие проекции.

Аннотация

В работе исследованы основные проблемы, с которыми приходиться сталкиваться специалистам в процессе выбора интеллектуальных рабочих мест (ИРМ), которые связаны с особенностями исходных данных, неточной формулировкой технического задания на систему, отсутствием единого критерия эффективности ИРМ. Рассмотрен подход к формированию ИРМ при создании электронной информационно-образовательной среды вуза с использованием математического аппарата нечетких множеств. На основе стандартного перечня характеристик предложена единая структура требований, позволяющая учитывать особенности ИРМ, как элемента автоматизированного обучения, так и особенности решения задач обработки учебной и управленческой информации. Наиболее существенными из требованиями является: быстродействие ИРМ, гибкость, универсальность и совместимость с системами управления и лабораторным оборудованием. При решении задачи выбора ИРМ для обработки учебной и управленческой информации предложено формализовать обобщенные требования в виде лингвистических оценок с использованием аппарата теории нечетких множеств и использовать структуру данных для представления параметров и требований к ИРМ. Разработан нечетко-множественный подход, позволяющий оценить сформированное ИРМ на основе предложенной структуры требований. Для описания информационного пространства предложена комбинация подходов логи-

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ко-лингвистического моделирования с использованием аппарата общей теории неопределенности и методики НЕ – факторов. Полученные оценки были агрегированы в итоговую оценку ИРМ. Предложенное моделирование позволяет устанавливать нечетко-множественную связь между входными параметрами ИРМ и ее соответствием предложенной системой требований. Полученные в работе результаты, позволяют формировать информационный образ выпускника современного вуза с использованием ИРМ.

Introduction

The development of the electronic information educational environment (EIOS) of the University, and as a tool for its implementation, the system of intellectual jobs (IPF) to increase the efficiency of the educational process in the modern University can be considered as a promising method of introducing innovative educational technologies [1-7].

Electronic information and educational environment (EIOS) is a set of information technologies, telecommunication technologies, appropriate technological means, electronic information and educational resources necessary and sufficient for the organization of indirect (at a distance) interaction of students with teaching, training and support, administrative and economic personnel, and among themselves [8-11].

The purpose of EIOS functioning in the University is to provide remote access to information and educational resources of the University and information openness of the University in accordance with the requirements of the current legislation of the Russian Federation in the field of education [12].

Features of EIOS for universities

The task of EIOS s at the University are determined in accordance with the goal. These are: 1) providing access to educational plans, work programs of disciplines (modules), practices, publications of electronic library systems and electronic educational resources (EER) specified in the working programs; 2) ensuring the recording of the educational process, the results of the intermediate certification and the results of the development of the basic educational program; 3) carrying out all types of classes, procedures for assessing the learning results, the implementation of which is provided with the use of e-learning, distance learning technologies; 4) the formation of an electronic portfolio of the student, including the preservation of the student's works, reviews and assessments of these works by the participants of the educational process; 5) interaction between the participants of the educational process, including synchronous and (or) asynchronous interaction through the Internet ; 6) ensuring access of students and employees of the University, regardless of their location to electronic information resources and electronic educational resources through the use of information and telecommunication technologies and services; 7) ensuring the individualization of the educational trajectory of the student; 8) improving the efficiency and quality of the educational process at the University; 9) providing mechanisms and procedures for monitoring the quality of the educational process; 10) ensuring information openness of the University.

Among the constituent elements of EIOS of University the following ones are allocated:

1. electronic information resources: web-portal of the University, the portal "Educational and methodological support of the main educational program», the web-site of the scientific library of the University;
2. electronic educational resources: the electronic library of the University, electronic library systems, electronic courses in the learning management system (for example, "Moodle" or "Prometheus"), reference and legal systems ("Consultant+", "Garant");
3. informational systems and telecommunication technologies: software complex of automation of educational process management, learning management system "Moodle", information system "Portfolio", information system "Antiplagiat", corporate computer testing system, information system for monitoring the effectiveness of activities, information system "Dissertation councils", web-portal of the University, portal "Educational and methodological support of the main educational program", web-site of the scientific library, reference and legal systems, corporate network and corporate e-mail of the University.

The structure of the electronic educational environment includes the following components [11]:

1. the official website of the University;
2. electronic library environment;
3. portal of the score-rating system of evaluation of learning results;
4. educational portal of distance learning system of students;
5. portal of creation and management of educational courses.

Clear requirements have now been formulated for the EIOS components. There are following [12]:

1. Functionality. This requirement is the presence in the system of a certain set of functions of different levels. For example, such functions include forums, chat rooms, management of courses and trainees, analysis of the activity of trainees and others.
2. Reliability. Such parameter as reliability is necessary in the process of implementation and operation of any electronic system, as an example of any complex system [14]. Its functions include not only the convenience and ease of updating content, but also protection from external influences [15-17]. This fact has a significant influence on the attitude of users to the system and the efficiency of its use.
3. Stable operation. Based on the degree of stability of the system in relation to different modes of operation.
4. Standards support. SCORM is a standard for content for e-learning courses. It is the international basis for the exchange of electronic courses [5]. If support isn't in system, it decreases its mobility, not allowing later to create portable courses.
5. The existence of a system of validation of knowledge. This requirement is aimed at assessing students ' knowledge online. To meet this requirement, it is possible to create tests and other control tasks that allow tracking the level of activity of students.
6. Usability. An important parameter that not only provides ease of

use of the system, but also allows making the system competitive in the e-learning market. Students will never use the technology that makes it difficult to operate. This requirement means that the system should be the most simple and clear, it should be easy to move from one section to another.

7. Availability of access. The use of technologies based on limited access significantly reduces the number of potential users. Therefore, trainees should not have obstacles to access to e-learning.
8. Prospects for the development of the platform. Any e-learning platform should be a developing and learning environment that includes improved versions of the system with support for modern technologies.
9. Quality technical support. This requirement is to support the efficiency, troubleshooting and vulnerabilities of the system, both with the help of specialists of the developer, and with the help of specialists of own support service.

These requirements are currently the basis for the evaluation and, accordingly, the selection of suitable EIOS components. Thus, on the basis of these requirements, a comparative study of platforms for e-learning in the NSPU of Kozma Minin "Moodle" and in PANEPA "Prometheus" was conducted. The results are presented in Table 1.

Table 1. The results of comparative study of platforms

Таблица 1. Результаты сравнительного исследования платформ

Platform parameters	Platform name	
	Moodle	Prometheus
	score	
Communication instruments		
- forums	1	1
- chats	1	1
- notification	1	0
- announcement	1	1
Training objects		
- tests	1	1
- training materials	1	1
- exercises	1	1
User data management		
- tracking	1	1
- statistics	1	1
- electronic portfolio	1	0
Usability		
- support	1	1
- the presence of the legal framework	1	1
Technical aspects		
- aspects	1	1
- security	1	1
- opportunity to train employees	1	0
Total score:	15	13

Table 1 highlights the main parameters that meet the stated requirements for e-learning. Therefore, the absence of some parameters can significantly affect the operation of the platform. It should be noted that in the considered platform "Moodle" has all the parameters (Fig. 1). This fact allows calling this platform full for e-learning. Thus, analyzing the results of the study of e-learning platforms "Moodle" and "Prometheus" in NSPU of Kozma Minin and PANEPA, respectively, should determine the impact of the lack of some criteria on the quality and effectiveness of distance learning. As for the "Prometheus", there is a lack of some parameter.

As follows from the description of the evaluation method, each parameter was assigned one of two possible values: "0" – is absent, "1" – is present. Such an assessment system is not always correct. The essence of the problem is that the individual parameters of the platforms are evaluated by different systems of indicators. In particular, it is necessary to assess not only the presence/absence of any service, but also to form an assessment of the quality of any service on a set of indicators. Finally, after the individual components (services) are collected together, the question arises: how to form the final evaluation of the EIOS of the University as a whole?

No less important is the question of how to implement EIOS of the University, and also methods of their evaluation.

In practice, EIOS of the University is implemented through the creation of intelligent workplaces (IPF), that is, a set of intelligent interfaces that provide access to all employees (participants of the educational process) to information resources and implemented in the form of software installed on a personal computer [6].

Any IPF can be subject to a number of general requirements, which must be provided at its creation, namely:

1. availability of information processing facilities;
2. ability to work in the dialog (interactive) mode;
3. meeting the basic requirements of ergonomics;
4. sufficient level of performance and reliability of the computer running in the (IPF) system;
5. software, which is adequate to the nature of the tasks to be solved;
6. maximum degree of automation of routine processes;
7. sufficient level of user service;
8. other factors that ensure maximum comfort and satisfaction of the specialist using IRM as a working tool.

Development trends and the level of tasks require inclusion in the list of necessary conditions for the effectiveness of the IRM and the availability of the intelligence of the software used, which is part of the IRM. The structure of the IRM includes three modules: a module for supporting the learning process; a module for planning classes; a module for intellectual support. In the structure of the University teacher IRM the following systems are presented:

1. calendar plans management;
2. student database management;
3. support of the learning process (electronic journal, schedule, etc.);
4. the replenishment of the knowledge base;
5. intelligent system of planning lessons;
6. expert system for issuing recommendations.

Modules are separate functional blocks, that is, they contain systems for performing some similar functions.

The choice of the functional blocks of the system the IRM, often conducted by one or two parameters: the speed, the completeness of the processing of educational information, in terms of reliability recognition standard learning situations. This approach is relatively simple, but does not take into account all the necessary factors, which can lead to a narrowing of the scope of the IRM. In selecting of IRM it needs the presence of multivariate information base on the existing samples. The task is to choose from this database of IRM that best meets the necessary quality indicators. The database should present technical and economic indicators and expert assessments of the IRM most widely used in Russian and some foreign universities. It is possible to draw up it on the basis of the synthesis of data provided in the information publications on the IRM. The increasing variety of types of IRM, quantitative and qualitative parameters characterizing them, determines the need to develop an automated selection procedure for IRM taking into account the features of the description of systems.

The main problems faced by specialists in the selection process are related to the features of the initial data, incorrect formulation of the technical specifications for the system, the lack of a single criterion of efficiency on the IRM [4].

The features of the initial data include: a significant number of types of industrial IRM produced in Russia and abroad, the presence of several sets of evaluation parameters, the presence of qualitative assessments of the IRM, the incompleteness of the initial data, the interdependence of parameters. In the formation of technical specifications for the IRM it often have to deal with very vague linguistic evaluation of the parameters of the IRM (for example, the completeness of the control of the educational process - high speed - low, etc.). In addition, it is necessary to take into account the degree of importance of a parameter in relation to the rest in solving a specific pedagogical or management tasks. This issue is of particular importance for different regions, where there are the specifics of the use of various information resources [9, 14, 18-23].

On the basis of the considered list of characteristics in this work, the structure of requirements (Table 2) is proposed, which allows to take into account the features of the IRM as an element of automated training and features of the task of processing training and management information. The requirements themselves represent desirable values for the characteristics of the system. The most common of them are the requirements for IRM performance, flexibility, versatility and compatibility with control systems and laboratory equipment.

From the point of view of speed (efficiency) to the IRM there are strict requirements of work in real time, as the data processing must take place at the pace of the educational process. The flexibility of the IRM provides the possibility of frequent change of tasks, speed and convenience of retraining. At the same time, depending on the specific application, department, faculty, administrative management, operating conditions, it is desirable to make a purposeful choice of the completeness of support of the educational process, the universality of the main components, the number of sources of source data and recipients of the resulting information, a number of other characteristics.

Table 2. Structure of demand to IRM

Таблица 2. Структура спроса на IRM

Demands				
To the hardware	To software means	To the educational information	Operational	Complex
By used types of computers	Time processings of element SUS	By necessary computer memory	Consumable power	Compatibility Complexity
By controllers	The volume	By speed	Supply voltage	Reliability and Security
By interface	Time of setting up and training IRM	By the solvability of learning objectives	By size and weight	
Resources available of ASU	Restrictions to the OP	By formality	Conditions operations	Universality Ergonomics
On compatibility with ULB	The probability of identification of the educational situation	By reliability source data	Economic effect	Adaptivity Openness

The use of fuzzy sets to define the requirements of IRM

In solving the problem of choosing the IRM for processing educational and management information, it is proposed to formalize the generalized requirements for it in the form of linguistic assessments using the apparatus of fuzzy set theory and to use the data structure to represent the parameters and requirements for the IRM presented in table 2.

For granulation of the relations of information space, a combination of approaches of logic-linguistic modeling of D. A. Pospelov with the mechanism of the general theory of uncertainty L. Zade and non-factors of A.S. Napiniani [24-33] is offered, based on generalized constraints and translation of the natural language phrases used for the speech target, into the language of generalized constraints of the type: *X isr R*, where *X* is a variable, *R* is a flexible, elastic constraint on this variable, and *isr* is a variable, in which *r* is a variable, and its value determines the way in which *R* limits *X*.

The cognitive frame (CF) is a "fuzzy frame" whose slots correspond to fuzzy or linguistic values»:

CF should be considered as a result of granulation of training information, in the form of a linguistic variable in which the family of fuzzy sets is compared to the term set. That is, it consists of normal fuzzy sets *F={A1,..., An}*, where any two adjacent sets have an overlap region. In this case, the domain of reasoning *X* must satisfy the conditions of fuzzy a-covering and the so-called semantic consistency, which are reduced to the following restrictions:

a) the number of elements of the set *F* is small (in accordance with Miller's law it is within 7+/-2);
b) every A_i - unimodal and normal fuzzy set;
c) neighboring fuzzy sets A_i, A_j should have a small overlap area (usually assumed that $A_i \cap < 0.5$).

As follows from table 2, based on the system of fuzzy conclusions, it is necessary to assess the level of compliance with the requirements of the obtained IRM for five sets of requirements:

1. to hardware;
2. to software;
3. to educational information;
4. operational;
5. complex.

Within each complex there is a division into five specific characteristics (for the fifth complex – into seven). For each characteristic, a breakdown can be carried out, for example, by two, three or more normal sets, a membership function can be constructed (see fig.1). For example, the performance characteristics can be characterized by three normal sets: "low speed", "medium speed" and "high speed" (in the same way can be characterized by the weight of the device, ergonomics, complexity, adaptability, etc.). Two normal sets ("low level" and "high level") can be characterized by such characteristics as, for example, the openness of the system or the reliability of the original data. Finally, such complex characteristics, as an economic effect or the probability of identification of the educational situation is required to characterize the five normal sets: "very low"," low"," medium", "high", "very high". Membership functions are determined on the basis of expert assessments.

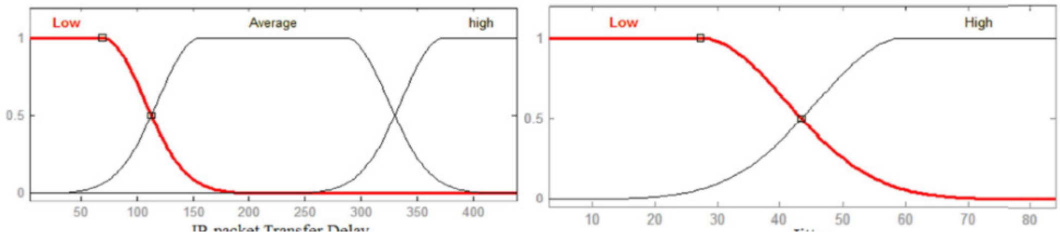

Fig. 1. Membership functions of fuzzy normal sets

Рис. 1. Функции принадлежности нечетких нормальных множеств

Thus, each of the 27 parameters of the "constructed" virtual IRM can be compared with the value of the membership function located on the interval [0,1]. The resulting estimates should then be aggregated by the final estimate of the IRM. It is possible to using the following methods for it:

1. a direct summation of the evaluation;
2. multiply them by appropriate weighting coefficients of the significance (as determined by expert assessments) with the subsequent summation;
3. aggregation based on fuzzy inference systems;
4. aggregation using systems of production rules (compiled with the help of expert assessments); a standard MATLAB package can be used with the help of FIS – editor (Fig. 2).

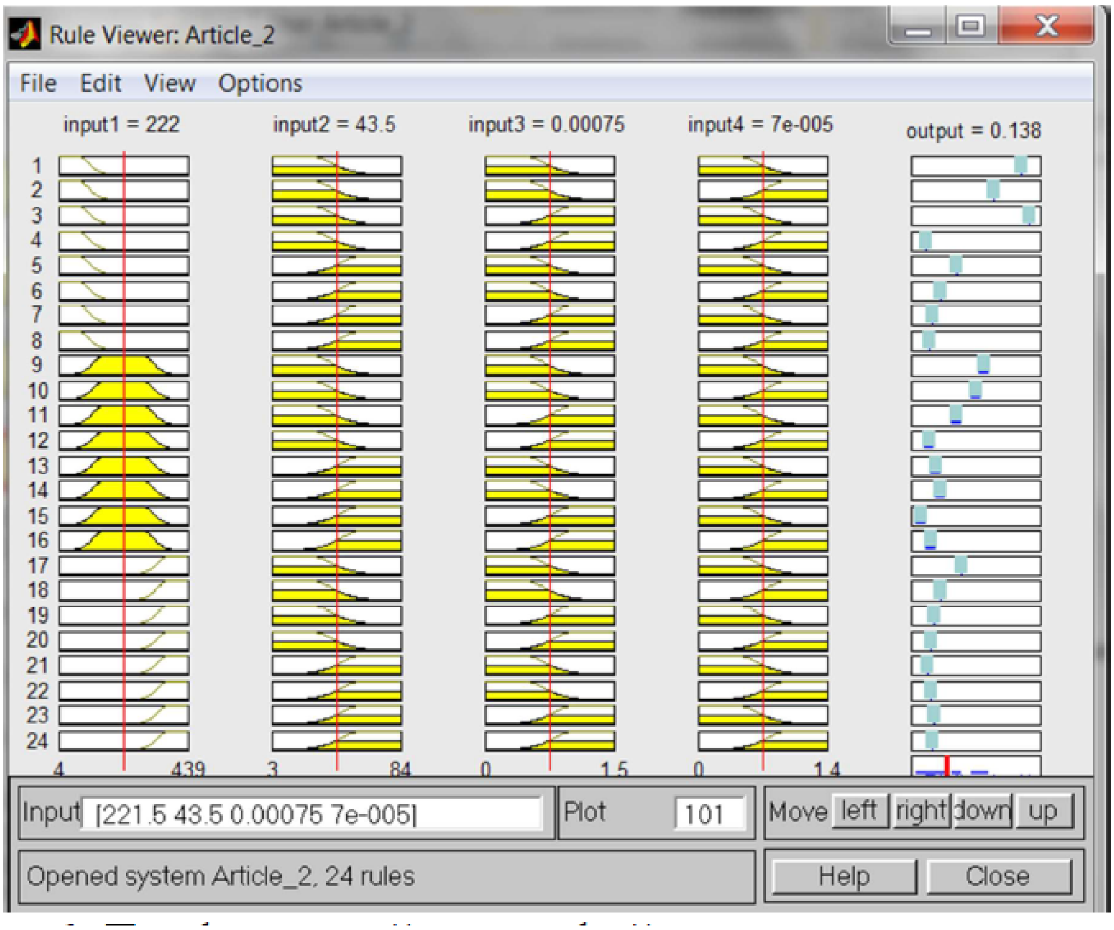

Fig. 2. Graphical interface for viewing the generated system of production rules in MATLAB

Рис. 2. Графический интерфейс для просмотра сгенерированной системы производственных правил в MATLAB

The proposed simulation will allow establishing a fuzzy-multiple relationship between the input parameters of the IRM and its compliance with the proposed system requirements.

Conclusion

Based on the analysis of the existing lists of characteristics of EIS and FIRMS in this paper, the structure of requirements is proposed, which allows taking into account the features of IRM as an element of automated training, and also the features of the task of processing educational and management information. The list of requirements is the desired values of the system characteristics. The most significant of them are the requirements for IRM performance, flexibility, versatility and compatibility with control systems and laboratory equipment. A fuzzy-multiple approach to the evaluation of the constructed IRM system is proposed, which allows to establish a fuzzy-multiple relationship between the input parameters of the IRM and its compliance with the proposed system of requirements.

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Submitted 21.04.2018; revised 15.06.2018; published online 30.06.2018.

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Поступила 21.04.2018; принята в печать 15.06.2018; опубликована онлайн 30.06.2018.

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