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Intelligent System of Distance Education of Engineers, based on Modern Innovative Technologies

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Abstract

Nowadays, distance education is a promising direction for the training of engineers. There was developed the intellectual system of distance education for the training of qualified specialists of technical specialties on the expensive modern equipment in the laboratories of collective use. Processing of personal data for the purpose of selecting an individual educational plan for each student is based on the biological approach of artificial immune systems.

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Keywords: Higher education institution, distance education, organizational learning, intellectual technologies, artificial immune systems, laboratories of a common use.

1. Introduction

Nowadays, there is an acute problem of quality technical education organization to train specialists for modern high technologies. Often, higher and postgraduate education is not available to skilled specialists because full-time training does not allow to improve the skills on the job.

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The problem may be exacerbated because of the geographical remoteness of potential students from higher education institutions. In such cases in the world there are used various mechanisms of the organization of the learning process. There was well proven a distance education (DE), which brings together various forms of education with the use of modern information technology. The world's leading universities with a long history practice a distance learning form, such as: University of South Africa[1] - one of the first university with DE, the British Open University[2] - the largest DE university, Fern University in Hagen[3], etc.

Distance education centers in Europe are the National Distance Education University[4] in Spain and the Baltic University. Nowadays, there is developed a huge amount of educational platforms that offer their DE courses, such as: Coursera[5]; EDX[6]; Udacity[7]; Open Yale Courses[8]; Teamtreehouse[9], etc. The DE organization is carried out by the Internet using special software (shells).

The most common shells are: Sharepointlms, JoomlaLMS, OpenNet and MOODLE (Modular Object-Oriented Dynamic Learning Environment). Due to the open source code MOODLE[10] became widely known, the system is translated into more than 75 languages and is used in almost 50 thousand organizations from 200 countries of the world.

There are carried out various researches in the sphere of DE, for instance, analysis of the dynamics and efficiency of distance learning implementation based on different countries (Australia, Saudi Arabia, Russia, Turkey) which are presented in works [1,2]. Approaches based on the use of different simulators in the DE are shown in work [3]. Modern approaches to improve traditional methods of teaching online [4] enhanced by the approaches of artificial intelligence (AI) and cognitive science. In work [5] the authors presented the latest developments in the DE field, such as the use of ontological models, the creation of virtual laboratories, open training systems, the use of artificial intelligence methods, etc. In addition to educational technologies there are carried out distance learning environment development for access to laboratories of a common use, thus the work [6] shows remote experimental system that allows students to have an access for distance researches to the photovoltaic module.

In connection with the above, in order to solve the problem of highly skilled engineering staff training and distance education courses there can be relevant to use approaches of AI, which are used in the processing of students personal data, in the creation of individual education plans, in processing of multidimensional data, in forecasting results and in operational adjustment of process of knowledge acquiring, as well as in the use of laboratories of a common use.

There is proposed the following structure of the article. The second section shows an intelligent system of distance education, which consists of two parts, the first part explains the principle of processing of students personal data on the basis of artificial immune system (AIS), and the second part describes the distance operation in laboratories of a common use. The conclusion is presented in the third section.

2. Intellectual system of distance education

2.1. Processing of students personal data on the basis of AIS

Due to the fact that the DE system is a large automated self-contained resource it is expedient to use modern intellectual approaches of creating an individual path and rapid adjustment of the educational process. There are

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[1] [http://www.unisa.ac.za/]
[2] [http: / /www.open.ac.uk/]
[3] [https://www.fernuni-hagen.de]
[4] [http://portal.uned.es/]
[5] [https://www.coursera.org]
[6] [https://www.edx.org]
[7] [https://www.udacity.com]
[8] [http://oyc.yale.edu]
[9] [http://teamtreehouse.com]
[10] [http://moodle.com]

widely used the following approach of AI: Neural Networks (NN) [7,8], genetic algorithms (GA) [9,10], artificial immune system (AIS) [11] and other systems.

There was developed intellectual distance education system (IDES) based on artificial immune systems [12-14].

Remark 1. Under the term artificial immune systems here are understood information technologies, which use the concept of theoretical immunology for various applications [15-17].

Remark 2. In the proposed approach of AIS as a mathematical model were taken the time series, which correspond to formal peptide (FP) [15] and the problem of image recognition based on the mechanisms of molecular recognition between the two peptides (antigens and antibodies) is solved.

Remark 3. There was developed intellectual technology of information processing by AIS, which consists of two key elements. The first task is an effective study of the immune network. An inclusion in the model the features with little effect on the output parameter complicates its use and leads to information redundancy, to the increase of learning time of the immune network, to the increase of computing resources and to the increase of errors in solving the problem of image recognition based on AIS. All this leads to a situation where the forecasting according to the redundant model is less effective than according to the model of the optimal number of features that have maximum informativeness.

The second major problem is the energy errors that inevitably arise in the processing of multidimensional data sets by the immune networks and during solving the problem of image recognition based on AIS. This problem is especially actual for structurally similar peptides that have roughly the same parameters and are at the boundaries of classes. Because of the energy errors they may be classified by mistake not in the right class.

Algorithm of data processing based on AIS is given below. The block diagram of the developed intellectual system based on the algorithm 1 is shown in Fig. 1.

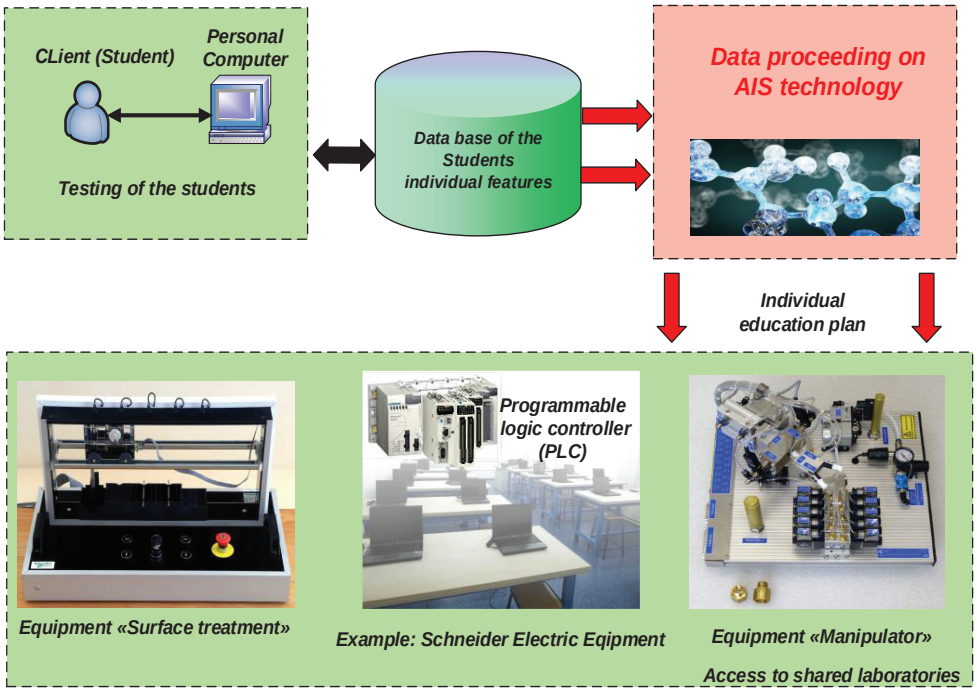

Fig. 1. The block diagram of DE.

Algorithm 1. Processing of students personal data on the basis of AIS.

(1) Testing. There is performed a basic test of the students on the studied disciplines, using the methods of psychology. Formed a psychological portrait of the students with a set of personal characteristics from the ability of information perception, to the availability of basic knowledge on the studied subjects.

(1.2) Individual Features. Based on the results of testing there are allocated individual attributes (IA) of each student.

(2) Data base. Then, the database on the basis of students IA is formed using Expert Knowledge Base.

(3) Preprocessing data. Information in IA databases is presented in the form of time series, and may be redundant, therefore before data processing there is conducted a pretreatment by various methods, such as normalization, centering, and filling the missing data.

(4) Data selection. in order to select the informative features there is used multi-algorithmic approach. It is based on the idea of using different methods of AI. For example, with the help of neural networks and NeuroShell software there can be distinguished an index of importance relative measure the of the parameter in the overall data set [13].

(5) Optimal structure of immune network. There is carried out the construction of the optimal structure of the immune network according to the coefficients of informative individual features, as well as the reduction of uninformative signs.

(6) Student's classification. Then, the students are classified according to the level of knowledge, skills, creativity, logical thinking based on the opinions of experts, as well as the desired profile engineering education is determined.

(7) Standard matrices forming. There is carried out the formation of the matrix standards:

$$\Re = \{\Re_1, \Re_2, \ldots, \Re_K\} \tag{1}$$

where K - the number of classes for each class according to the informative features of the students with an optimal structure, singular value decomposition of the data matrix and determination of right and left singular vectors:

$$\{x_1, y_1\}, \{x_2, y_2\}, \ldots, \{x_n, y_n\} \tag{2}$$

where n – the number of standard matrices [15-17].

Standard matrices $\Re$ are considered as antigens.

(8) AIS teaching. After the construction of the optimal structure of the immune network there is required its training according to the standards, which is carried out with the help of a teacher.

(9) Image matrices forming. Then there are formed image matrices on individual features of students:

$$\Im = \{\Im_1, \Im_2, \ldots, \Im_n\} \tag{3}$$

where n – the number of images. Image matrices are considered as antigens.

(10) Definition of the binding energy minimum. There is calculated the minimum value of the binding energy between formal peptides [15] - antigens and antibodies, and is solved the problem of image recognition:

$$\varpi_1 = -x_1^T \Im_1 y_1, \varpi_2 = -x_2^T \Im y_2, \varpi_n = -x_n^T \Im_n y_n \tag{4}$$

Remark 4. As in the AIS approach the term binding network means any binding sequence of the formal peptides, then in order to build an immune network model.

The minimum value ϖ shows the class to which the image belongs to:

$$K : \varpi_n = \min \{\varpi_1, \varpi_2, \varpi_r\} \quad (5)$$

(11) Estimation of the energy errors. This assessment is based on the properties of homologous proteins [16]. There is implemented a calculation of a Z – factor. The value of a Z-factor is determined by the average number of standard deviations between the energy of the native structure and the energy of a random chain placement [14].

(11.1) Definition of the risk coefficients. There is carried out the recognition of protein structure according to the homologies and determination of the reliability of the forecast on the basis of AIS, depending on the value of Z - factor. There are calculated risk factors:

$$K_R = |1 - Z_i|, \; i = \overline{1, m} \quad (6)$$

where m - the number of homogeneous peptides. As the technical implementation there is used a copyright software application package MATLAB [14].

(12) Estimation of the knowledge, decision-making. After the processing of students personal data there is carried out a comprehensive assessment of students knowledge, grouping on classes, forecasting the quality of received education by each student and prompt management of distance education process in the Internet environment. There are created the student's individual education plan based on combining of ready-made models of disciplines.

An example of a discipline model on 3 credits used in the "Automation and Control" department at Kazakh National Technical Research University named after K.I. Satpaev (KazNTRU) for teaching graduate profile for technical specialties is presented in Fig. 2.

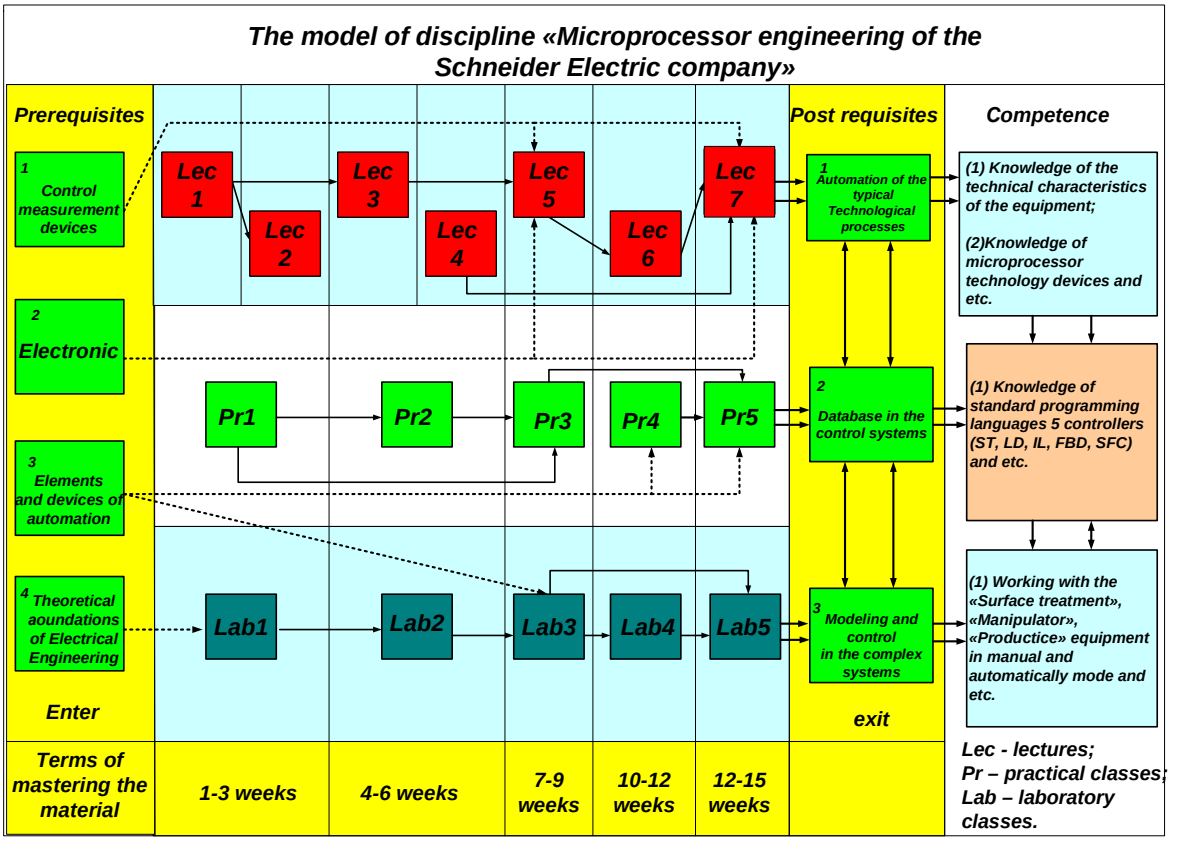

Fig. 2. An example of a discipline model "Microprocessor engineering of Schneider Electric company".

The advantage of this algorithm is: energy errors assessment based on the properties of homologous proteins in solving the problem of image recognition; the ability to assess the images that are on the boundary of classes, in order to avoid erroneous choice of education direction; reduction of errors in energy assessments, improving the reliability of the forecasting and the quality of education.

3. Access to the laboratories of a common use

The DE intelligent system is designed for laboratories of a common use in "Kazakh-French educational center in the field of energy, electronics and maintenance of automated systems - Schneider Electric" (KazFEC) in KazNTRU. The lab potential is a modern industrial equipment in the field of microprocessor technology of Schneider Electric company. The software and equipment have the capacity of DE organization via OPC server (to read the data from the actual controller) and is to use software Unity Pro L and OPC Factory Server, which are capable to operate in a simulator mode. Simulation software of Unity Pro L allows to search errors in the project without regard to the actual programmable logical controller (PLC). All project tasks (Mast, Fast, AUX and Event), which are executed at the current PLC are also available in the simulator. Along with the program Unity Pro L the program of OPC Factory Server (OFS) can also operate in simulation mode. There are three ways to access the OPC server: in local mode, access through the classic DCOM configuration, network access through the INTERNET interface HTTP. Distance education via an OPC server with real equipment is proposed according to the following Algorithm 2.

Algorithm 2. Access to the laboratories on the basis KazFEC.

(1) The student gets an access to a server that is connected with the database;
(2) Downloads the necessary software and the task on his computer;
(3) Makes the adjustment of simulators.
(4) Makes the exercises in accordance with the task on designing a control system in the simulator mode.
(5) Tests the developed control systems.
(6) In the case of the correct execution of the exercises the student gets an access to the actual hardware through the INTERNET to test his program in standard connection mode.

4. Conclusion

The proposed technology gives a wide range of possibilities for the establishment of a multilateral exchange of information between DE intelligent system based on AIS and real expensive equipment in the laboratories of a common use. Students of different target groups, including current employees of the enterprises, have the DE ability at work. Analysis of the personal data with the help of AIS allows to make individual learning direction based on modular training courses. Remote access to modern equipment makes it possible to obtain unique skills necessary for quality professional training in real time.

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