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НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
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COGNITIVE SMART-TECHNOLOGY OF DISTANCE LEARNING OF EXPERION PKS DISTRIBUTED CONTROL SYSTEM FOR OIL AND GAS INDUSTRY USING ONTOLOGICAL APPROACH

Abstract. The research is devoted to the actual problem of qualified engineering personnel training for the oil and gas industry of the Honeywell company industrial equipment. There has been developed a cognitive Smart-technology of distance learning of engineers in shared laboratories of Experion PKS distributed control system equipment, which is currently widely used to solve a set of tasks from data collection and processing to technological processes operating modes optimization at refineries. The application of the proposed technology allows to provide high-quality personalized distance learning using ontological models that are designed to analyze the structure of DL, to systematize the input and output data, as well as significantly to improve the quality of the developed complex software. The advantage of the proposed Smart-technology of DL is the use of cognitive methods for the dynamic presentation of educational information using cognitive-visual schemes depending on the type of central nervous system of the student: choleric, sanguine, melancholic or phlegmatic, as well as features of vision in order to improve learning efficiency. Taking into account the individual characteristics of the perception of educational information there was created a personalized learning trajectory. An important feature of the technology is the processing of multidimensional data using a bioinspired approach of artificial immune systems in order to predict learning results and prompt adjustment of the industrial equipment development process.

Key words: distance learning, Smart-technology, ontological approach, shared laboratories, Experion PKS industrial equipment, cognitive methods.

Introduction. Nowadays, the actual problem is qualified engineering personnel training in the oil and gas industry on modern industrial equipment. The development of innovative distance learning technologies for effective training of specialists in shared laboratories (SL) on industrial equipment of leading manufacturers is relevant. Since 1974, Honeywell company has been developing distributed control systems (DCS) and is currently a leading company in the Fortune 100 rating in the field of industrial equipment for various purposes [1]. Honeywell equipment is successfully used in the oil and gas and chemical industries, for the production of turbo compressors, in industrial automation, etc. The company pays special attention to training centers and training courses. There are a large number of colleges around the world: in Germany (Honeywell Process Solutions); in France (Honeywell French Automation College); in Russia (Honeywell Russia Automation College), etc. The company invests heavily the development of E-Learning and offers various virtual trainings. The platform Experion PKS (Process Knowledge System) by Honeywell, which is a set of high-tech tools for solving various automation tasks [2], is especially widely used and is often used at refineries.

The progress in the field of high technology and the creation of the Internet allowed to modernize the sphere of higher education and one of the promising direction is distance learning (DL). The purpose of implementation of distance learning technologies in the system of engineering education is to ensure the availability of obtaining knowledge for students, regardless of their place of residence, social status, health

status, distance from the training center [3], etc. Development and implementation of innovative distance learning technologies using modern approaches of artificial intelligence and telecommunication means, which provide a highly effective interactive method of obtaining knowledge, is a new level of interaction between the teacher and the student, aimed at improving the quality of training and development of complex technological equipment.

Literature analysis. Shared laboratories (SL) create a platform for research, technological and engineering activities and provide open access to expensive industrial equipment. For example, the researchers [4] consider various learning styles that determine the cognitive and psychosocial behavior of students, the knowledge perception, interaction and information processing in various learning environments. There is given an evaluation of the styles effectiveness for laboratory training through a web-platform. The work [5] is devoted to the issues of efficient maintenance of distributed remote laboratories.

The studies [6] consider the need to use the latest remote information technologies in educational process organization in the system of higher technical education, due to the fact that traditional approaches categorically do not meet the needs of a rapidly developing society, that contradicts the real needs of main consumers of educational services. The article [7] is devoted to the issues of the DL advantages in connection with the great adaptability to the needs of students, the wide possibilities of modern high technologies use, telecommunication and multimedia tools in order to improve the education quality. The research [8] raises the issue of the student training quality. The rapid development of online higher education leads to the fact that students are faced with certain barriers that affect the general DL quality. These problems are solved by the use and by the implementation of effective DL methods and by the latest information and communication technologies. Despite the advantages of DL there is a high percentage of student dropouts. The work [9] is devoted to the solution of this problem. There has been carried out the analysis and have been developed measures that help to reduce the dropout rate from the distance learning system on the basis of a deep level of personnel interest and learning process personalization. The conducted researches and available data confirm the effectiveness of their application. The article [10] presents a comparative analysis of the traditional system of education and distance education. The effectiveness of DL as a supplement to the traditional form of education is also shown.

The implementation of modern information Smart-technologies using the latest achievements of artificial intelligence in the field of DL contributes to the development of intellectual abilities of students and to the improvement of the education quality. The article [11] defines Smart-learning, based on the use of digital technologies and DL empowering. The development of various cognitive DL methods in order to take into account the characteristics of information perception by students is relevant. The article [12] proposes a Smart-technology of DL using cognitive learning tools that solves the problem of accessibility of education and is aimed at developing the mental abilities of students. The article [13] deals with issues of interactive learning in the intellectual environment. There are proposed various training scenarios that illustrate the implementation of new educational models aimed at the adaptation and individualization of knowledge acquisition. The general purpose of both learning scenarios is to improve learning for different groups, moving away from a teacher-based approach to a student-centered approach.

A great importance at the development of innovative Smart-systems of distance learning has the development and the use of ontological models, which allow to systematize and to structure the data [14]. Ontologies are widely used in solving problems of knowledge representation in various applied areas, including in the field of DL. Analysis of ontological models allows to take into account the peculiarities of functioning and interconnection during the work of various algorithms of artificial intelligence, reduces the time and computational costs on the development of software for the implementation of Smart-technologies of DL. The article [15] describes the ontological learning model, which contains the psychological characteristics and personality traits of the learner. The research [16] is devoted to the creation of ontological models that characterize students in the ontology editor Protégé. In the work [17], there is considered the problem of creation of the large-scale ontologies and their practical use. The article [18] presents the ontological student's network model for learning environments. This model is developed as a set of ontological resources that have been expanded, standardized, interconnected and adapted for the use in various learning environments.

The proposed researches are a continuation of the cycle of works devoted to distance learning of engineering specialties. For example, the work [19] considers the need to process a huge flow of

multidimensional data in real time arising from the operation of modern DL systems, problems associated with the huge number of unaccounted factors affecting the system and the ability to connect to real equipment. With DL there is a very large load on the eyesight [20], therefore, the development of a specialized DL system for people with visual disabilities is urgent.

Problem statement and solution methods. It is necessary to develop a cognitive Smart-technology of DL equipment for the Experion PKS distributed control system of Honeywell company for the oil and gas industry in shared laboratories using ontological models and an approach of artificial immune systems, taking into account students' perception of educational information depending on their psychotype and visual characteristics in order to improve learning process.

Figure shows the structure of the cognitive DL Smart-technology to the Experion PKS industrial equipment.

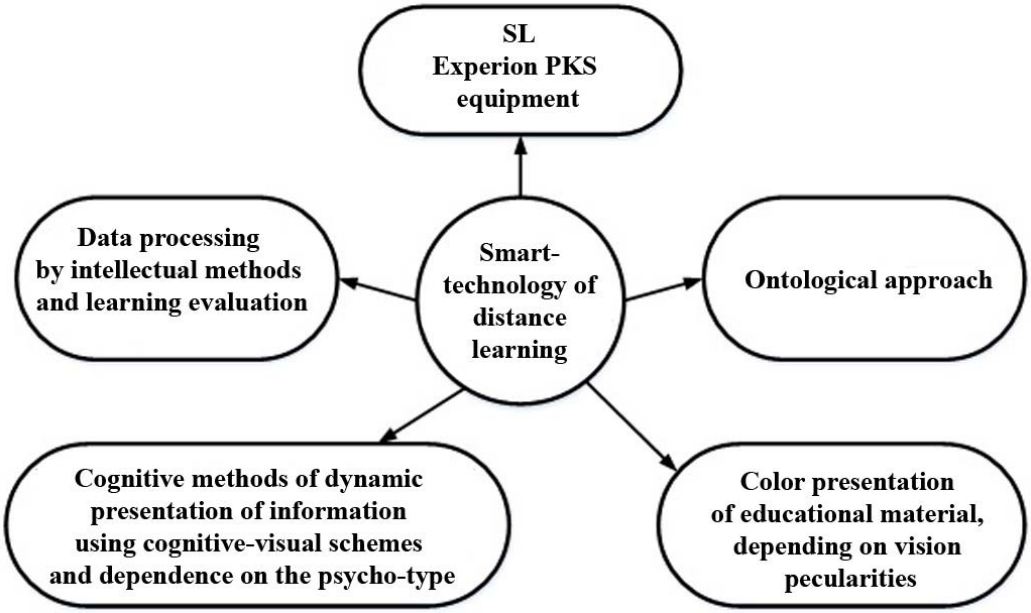
The main features of the proposed technology are:

1. Development of ontological models for structuring the information DL system, systematization of input and output data, identification of logical links, and development of software.

2. Introduction of cognitive methods of dynamic presentation of educational information using personalized cognitive-visual schemes depending on the student's psychotype (choleric, sanguine, melancholic or phlegmatic) and vision peculiarities (myopia and hyperopia).

3. Application of the modified Artificial Immune Systems (AIS) algorithm for processing individual characteristics (descriptors) of students and for prediction learning results, as well as operational control of the process of obtaining knowledge based on the learning evaluation.

4. Shared laboratories for solving the assigned task of distance learning should have a complete infrastructure: modern equipment, appropriate technical and software support.



Cognitive DL Smart-technology to the Experion PKS industrial equipment

The Experion PKS platform is a multi-layered architecture for solving complex tasks from collecting and processing information to optimization of operating modes of technological processes and is widely used in the oil and gas industry [2]. This platform largely interacts with a large amount of advanced control, planning and automation subsystems, alarms, security and access control subsystems, thereby providing the necessary level of integration and interaction between all components of the control systems. The use of a fault-tolerant industrial network (FTE) provides the connection of all control nodes, but at the same time has a number of characteristics that allow maintaining a high level of reliability and security, as well as the ability to work with equipment from other manufacturers. At connecting field devices via digital interfaces, not only the measurement channel error is reduced, but it also ensures the extended information obtaining. The use of a universal digital interface (HART protocol) allows remote

monitoring and configuration of communication channels. The main feature of Experion PKS is the built-in “server consolidation” technology - DSA (Distributed Server Architecture). DSA technology provides unified access not only to real-time data (configured points), but also to the trends and history logs. This makes it possible quickly to respond and to make decisions through access to the necessary information.

Ontological models. Table presents the following ontological models: shared laboratories with the use of the Experion PKS distributed control system equipment, the ontological model of teaching the Experion PKS equipment; ontological model of a student taking into account psychotypes and visual peculiarities.

Ontological models of DL in SL with Experion PKS equipment

Ontological models	Content
1	2
1. Ontological model of SL with the Experion PKS equipment of the Honeywell company	*Download and connection of software for the Experion PKS system.*
	Creation of an operator account in the Station program: - opening the operator panel using Enter System Menu and System Configuration; - creation of an operator account (selecting Operators) to Configuration Studio access; - log in to the system under the created operator account.
	Creation of an enterprise model database (EMDB, Enterprise Model DataBase): - download an EMDB system using Knowledge Builder program; - connection and loading of the configured server into the EMDB system; - creation and configuration of Asset Model in the Enterprise Model Builder application for the selected control object; - download the Asset Model to the EMDB system; - creation of an Alarm Group in the Enterprise Model Builder application and connection to the Asset Model; - download of Alarm Group to EMDB system.
	Creation of a SCADA system: - selection of Control Strategy command; - creation and configuration of a communication channel (Build Channels) in Quick Builder application; - connection of a communication channel using Ethernet in order to work with controllers using OPC technology; - checking the connection of the communication channel in the Station program, where statistical data are automatically recorded; - selection of the controller type (Modbus, UserScanTask, Allen-Bradley, FSC) and connection to the communication channel and download; - checking the connection of the controller in Station; - if the controller is not connected, then select “Controllers” in the System Configuration system and connection of the controller using the left mouse button on the “Enable” checkbox; - selection and configuration of the sensor "points" (Points) by signal type: Accumulator Point, Analog Point, Container Point, Status Point; -connection and loading Points: to the communication channel, controller, Asset Model (control object), Alarm Group; - checking the connection of Point in the Station; - in order to control the Point state, the name Point is entered in the Command Zone and by the left mouse button on Detail opens the created point through which it can be controlled; - point status control; - view the status of the Alarm Zone; - viewing time control in History from 1 hour to 1 minute.
	Creation of an interactive operator display and setting up the information presentation from a display reflecting the front panel of the control circuit: - a data structure of the display is compiled for several field values at one point with different parameters; - Analog Point for control circuit (PV, SP, OP, Mode, Aux1-4, Alarms). StatusPoint for valve (PV, OP, Mode, Alarms). Where PV (process value) is the process variable, OP (output) is the output variable, SP is the specified value of the measured parameter (setpoint), MD is the mode for loop changing from manual to automatic control; - creation of a working group display and of a trend for each point in the server database; - definition of Analog Point or Status Point and the display name in (Group Face Template Display) for working with the front panel of the operator; - creation of groups configuration Configure Groups in the application Trends and Groups in the field Title Definition;

	- point identification and point description (Point IDs and Point Descriptions) using the Point Browser window; - definition of the working group and observation of working data for each point from one display, if your server is connected to the controller and is in operation mode; - work with an interactive display that combines the characteristics of standard group and trends displays.
2. Ontological model of Experion PKS equipment learning	*Lectures*: - Lecture 1. Introduction to the Experion PKS platform; - Lecture 2. Work with the Station program. …
	Laboratory classes: - Lab. 1. Access to the Station program using protection level data; - Lab. 2. Launch of Configuration Studio, which performs access configuration and system simulation tasks. ...
	Independent work: - Topic 1. Connection of the controllers to the server using communication channels, as well as determination of the controller type and communication line type; - Topic 2. Configuration of the trend in the application Configuration Studio. ...
	Educational materials: - Experion PKS. Product guide. 2004. Honeywell. …
3. Ontological model of the student taking into account psychotypes and vision peculiarities	*The use of a cognitive approach in order to identify the physiological, intellectual and psycho-physiological features of the perception and awareness of information:* - questionnaire in order to determine the individual characteristics by the psychotype: 1. choleric (strengths: active, confident, pragmatist, creative; weaknesses: domineering, irritable, hot-tempered); 2. sanguine: (strengths: enthusiastic, sociable, talkative; weaknesses: unorganized, undisciplined); 3. phlegmatic: ... 4. melancholic: ... - selection of the optimal training tactics, taking into account the individual vision peculiarities 1. with myopia; 2. with hyperopia; - development of a database of individual descriptors of students; - processing of multidimensional data on the basis of modified AIS algorithm; - formation of individual cognitive visual schemes; - dynamic presentation of information, taking into account the vision peculiarities and psychotype; - prediction of learning results and operational control of the knowledge obtaining process based on the learning evaluation.

The developed ontological models are implemented in the Protégé ontology editor.

Conclusion. The conducted researches on creating innovative cognitive Smart- technologies [21] of distance learning of engineering specialties in shared laboratories of distributed control equipment at Experion PKS of the Honeywell company using an ontological approach and artificial immune systems are relevant and are aimed at effective personalized distance learning, taking into account information perception features (depending on psychotype and visual acuity) and the preparation of highly professional specialists in the oil and gas industry [22].

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МҰНАЙГАЗ САЛАСЫ ҮШІН ОНТОЛОГИЯЛЫҚ ТӘСІЛДІ ҚОЛДАНА ОТЫРЫП EXPERION PKS ЖАБДЫҒЫН ҚАШЫҚТАН ОҚЫТУДЫҢ КОГНИТИВТІ SMART-ТЕХНОЛОГИЯСЫ

Аннотация. Зерттеулер мұнайгаз саласындағы Honeywell (Honeywell) фирмасының өнеркәсіптік жабдығы үшін мамандандырылған инженерлік кадрларды дайындаудағы өзекті мәселеге арналған. Кешенді техникалық автоматтандырылған құрылғыларын өндіруден Honeywell компониясы әлемдік көшбасшы болып саналалы. Honeywell құрылғылары аэроғарыш, мұнай-газ және басқа да өндіріс салаларында сәтті қолданысқа ие. Автоматты түрде реттеуге, қашықтықтан басқаруға, жинақтау және деректерді өңдеуге, ақпараттарды графикалық бейнелеуге, есептерді қалыптастыруға, журналдарды мұрағаттауға, ақпарат алмасуға және т.б. функцияларды атқаратын қуатты Experion PKS реттелген басқару жүйесін Honeywell корпорациясы әзірлеген.

Қазіргі уақытта мұнайөңдеу зауыттарында ақпаратты жинау және өңдеуден бастап технологиялық үрдерістердің жұмыс істеу тәртібін оңтайлаландыруға дейінгі міндеттердің жиынтығын шешу үшін кеңінен пайланылатын ұжымдық пайдалану зертханаларында инженерлерді Experion PKS жабдығын қашықтан оқытудың когнитивті Smart-технологиясы жасалды. Ұсынылған технологияларды қолдану − ҚО құрылысын талдауға, кіріс және шығыс деректерді жүйелеуге арналған онтологиялық модельдерді пайдалана отырып сапалы дербестендірілген қашықтан оқытуды қамтамасыз етуге мүмкіндік береді, сондай-ақ, жасалған күрделі бағдарламалық қамтудың сапасын айтарлықтай арттырады. Ұсынылып отырған ҚО Smart-технологиясының артықшылығы оқытудың тиімділігін арттыру үшін оқушының холерик, сангвиник, меланхолик немесе флегматик сияқты орталық жүйке жүйесінің типіне, сонымен қатар көру ерекшеліктеріне байланысты оқу ақпараттарын когнитивті-визуалды сызбалардың көмегімен динамикалық тұрғыда берудің когнитивті әдістерін қолданумен байланысты. Оқу ақпаратын қабылдаудың жеке сипаттамаларын ескере отырып, оқытудың дербестендірілген траекториясы тұрғызылады. Технологияның маңызды ерекшелігі оқытудың нәтижелерін болжау және өнеркәсіптік жабдықтарды игеру үдерістерін шұғыл түзету үшін жасанды иммундық жүйелердің биоинсперирленген тәсілін пайдалана отырып, көпөлшемді деректерді өңдеуде жатыр.

Түйін сөздер: қашықтан оқыту, Smart-технология, онтологиялық тәсіл, зертханаларды ұжымдық пайдалану, Experion PKS өнеркәсіптік жабдығы, когнитивті әдістер.

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КОГНИТИВНАЯ SMART-ТЕХНОЛОГИЯ ДИСТАНЦИОННОГО ОБУЧЕНИЯ РАСПРЕДЕЛЕННОЙ СИСТЕМЫ УПРАВЛЕНИЯ EXPERION PKS ДЛЯ НЕФТЕГАЗОВОЙ ОТРАСЛИ С ПРИМЕНЕНИЕМ ОНТОЛОГИЧЕСКОГО ПОДХОДА

Аннотация. Исследования посвящены актуальной проблеме подготовки квалифицированных инженерных кадров для нефтегазовой отрасли промышленному оборудованию фирмы Honeywell. Компания Honeywell является мировым лидером в области производства комплекса технических средств автоматизации. Оборудование Honeywell успешно применяется в аэрокосмической, нефтегазовой и других областях промышленности. Корпорацией Honeywell разработана мощная распределённая система управления Experion PKS, которая выполняет функции: автоматического регулирования, дистанционного управления, сбора и обработки данных, графического отображения информации, формирования отчетов, архивирования журналов, обмена информацией и т.д.

Разработана когнитивная Smart-технология дистанционного обучения инженеров в лабораториях коллективного пользования оборудованию распределенной системы управления Experion PKS, которое в настоящее время широко используется для решения комплекса задач от сбора и обработки информации до оптимизации режимов работы технологических процессов на нефтеперерабатывающих заводах. Применение предлагаемой технологии позволяет обеспечивать качественное персонализированное дистанционное обучение с использованием онтологических моделей, которые предназначены для анализа структуры ДО, систематизации входных и выходных данных, а также существенно повышают качество разрабатываемого сложного программного обеспечения. Достоинством предлагаемой Smart-технологии ДО является применение когнитивных методик динамической подачи учебной информации с помощью когнитивно-визуальных схем в зависимости от типа центральной нервной системы обучающегося: холерика, сангвиника, меланхолика или флегматика, а также особенностей зрения для повышения эффективности обучения. С учетом индивидуальных характеристик восприятия учебной информации строится персонализированная траектория обучения. Важной особенностью технологии является обработка многомерных данных с использованием биоинсперированного подхода искусственных иммунных систем для прогнозирования результатов обучения и оперативной корректировки процесса освоения промышленного оборудования.

Ключевые слова: дистанционное обучение, Smart-технология, онтологический подход, лаборатории коллективного пользования, промышленное оборудование Experion PKS, когнитивные методики.

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