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OWL-модель мультиагентной Smart-системы дистанционного обучения людей с ограниченными возможностями зрения

Целью исследования *является разработка онтологической модели мультиагентной smart-системы дистанционного обучения для людей с ограниченными возможностями зрения на основе платформы Java Agent Development Framework, с целью получения качественного инженерного образования в лабораториях коллективного пользования на современном оборудовании.*

Материалы и методы исследования. *При разработке мультиагентной smart-системы дистанционного обучения актуально использование различных агентов на основе применения когнитивного, онтологического, статистического и интеллектуального методов. Наиболее удобно реализовывать данную задачу в виде программного обеспечения с помощью мультиагентного подхода и платформы Java Agent Development Framework. Основными преимуществами платформы являются такие факторы как: стабильность работы, понятный интерфейс, простота создания агентов и обширная база пользователей. В мультиагентных системах решение получается автоматически в результате взаимодействия множества самостоятельных целенаправленных агентов. Каждый агент может выполнять определенные задачи и преследует заданные цели. Рассмотрены интеллектуальные мультиагентные системы и созданные на их основе практические приложения в дистанционном обучении.*

Результаты. *Разработана структурная схема функционирования smart-системы дистанционного обучения для людей с ограниченными возможностями зрения с использованием различных агентов, реализованная на основе системного подхода и мультиагентной платформы Java Agent Development Framework. Предложен комплексный подход дистанционного обучения лиц с ограниченными возможностями зрения для получения качественного инженерного образования в лабораториях коллективного пользования на современном оборудовании.*

Создана онтологическая модель мультиагентной smart-системы с подробным описанием функций следующих агентов: персонального, менеджера, онтологического, когнитивного, статистического, интеллектуального, агента лаборатории коллективного пользования, агента здоровья, агента помощника и государственного агента. Данные агенты выполняют свои индивидуальные функции и обеспечивают качественную среду обучения.

Заключение. *Таким образом, предлагаемая smart-система дистанционного обучения людей с ограниченными возможностями зрения позволяет существенно повысить эффективность и качество получаемого образования данной категорией людей. Особенностью применения разработанной онтологической модели smart-системы дистанционного обучения для людей с ограниченными возможностями зрения на основе многофункциональных агентов является: комплексный подход на основе использования различных интеллектуальных, когнитивных и статистических методов; возможность разработки индивидуальной траектории обучения людей с ограниченными возможностями зрения с учетом психофизиологических особенностей восприятия информации; дистанционный доступ к новейшему технологическому оборудованию для выполнения лабораторных, практических работ людей с ограниченными возможностями зрения в лабораториях коллективного пользования в режиме реального времени. Онтологическая модель позволяет глубже проанализировать многочисленные связи между агентами и учитывать их при разработке программного обеспечения smart-системы дистанционного обучения людей с ограниченными возможностями зрения. Мультиагентный подход обеспечивает многофункциональность системы, устойчивость к системным ошибкам, а также оптимизацию вычислительных ресурсов.*

Ключевые слова: *дистанционное обучение, люди с ограниченными возможностями зрения, мультиагентная smart-система, OWL модель.*

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OWL model of multi-agent Smart-system of distance learning for people with vision disabilities

The aim of the study *is to develop an ontological model of multi-agent smart-system of distance learning for visually impaired people based on Java Agent Development Framework for obtaining high-quality engineering education in laboratories of join use on modern equipment.*

Materials and methods of research. *In developing multi-agent smart-system of distance learning, using various agents based on cognitive, ontological, statistical and intellectual methods is important. It is more convenient to implement this task in the form of software using multi-agent approach and Java Agent Development Framework. The main advantages of the platform are stability of operation, clear interface, simplicity of creating agents and extensive user database. In multi-agent systems, the solution is obtained automatically as result of interaction of many independent, purposeful agents. Each agent can perform certain tasks and pursue specified goals. Intellectual multi-agent systems and practical applications in distance learning based on them are considered.*

Results. *The structural diagram of functioning of smart system distance learning for visually impaired people using various agents based on the system approach and the multi-agent platform Java*

Agent Development Framework is developed. The complex approach of distance learning of visually impaired people for obtaining high-quality engineering education in laboratories of joint use on modern equipment is offered.
The ontological model of multi-agent smart-system with a detailed description of the functions of following agents is created: personal, manager, ontological, cognitive, statistical, intellectual, shared laboratory agent, health agent, assistant to the agent and state agent. These agents execute their individual functions and provide a quality environment for learning.
Conclusion. *Thus, the proposed smart-system of distance learning for visually impaired people can significantly improve effectiveness and quality of the received education of this category of people. The benefits of using of the developed ontological model of smart-system of distance learning for visually impaired people based on multifunctional agents are: complex approach, based on the use of various intellectual, cognitive and statistical methods; possibility of developing an individual trajectory of learning for visually impaired people including the psychophysiological features of perception information; distance access to the latest technological equipment for performing laboratory and practical works by visually impaired people in the shared laboratories in real time. The ontological model provides to analyze more deeply the numerous connections between agents and considers it in developing software for smart-system of distance learning for visually impaired people. Multi-agent approach provides multi functionality of system, stability to system errors, and optimization of computing resources.*

Keywords: *distance learning, people with vision disabilities, multi-agent smart-system, OWL model.*

1. Introduction

Nowadays, distance learning (DL) is widely used to obtain affordable, quality and effective education. Modern DL is characterized by flexibility and versatility, which allows it to compete with traditional learning systems [1]. In connection with the rapid development of computer technology and artificial intelligence, modern innovative DL technologies are being actively developed to improve the quality and the effectiveness of learning. The smart-systems of distance learning and smart-technologies, which have opportunities to provide a high level of knowledge are of a great interest [2, 3]. Such smart-systems of DL provide an effective learning environment based on artificial neural networks [4], evolutionary algorithms, artificial immune systems, and are used to predict learning outcomes, to analyze multidimensional data, to extract informative features, and for statistical data processing and etc.

In modern DL it is important to receive a high-quality education on engineering specialties using the latest high-tech equipment in shared laboratories. The study of new technologies has great importance for the implementation of a full-fledged communication between students with various disabilities and society [5, 6]. This category of people faces to learning difficulties in traditional DL systems and needs in the creation of specialized systems [7]. Especially important is the development of such learning systems for people with visual disabilities, as many people in the world have vision problems. Organization of the process of e-learning involves spending a lot of time at the computer, which negatively affects the visual apparatus. The creation of such specialized systems, aimed at adapting people with impaired vision (PIV) in society, is one of the important problems of modern distance education.

The use of system and agent-based approaches is relevant at the development of DL information systems.

The use of MAS in the development of modern applications in the field of DL is convenient for implementing various intellectual approaches. ducation on engineering specialties using the latest high-tech equipment in shared laboratories. The study of new technologies has great importance for the implementation of a full-fledged communication between students with various disabilities and society [5, 6]. This category of people faces to learning difficulties in traditional DL systems and needs in the creation of specialized systems [7]. Especially important is the development of such learning systems for people with visual disabilities, as many people in the world have vision problems. Organization of the process of e-learning involves spending a lot of time at the computer, which negatively affects the visual apparatus. The creation of such specialized systems, aimed at adapting people with impaired vision (PIV) in society, is one of the important problems of modern distance education.

The use of system and agent-based approaches is relevant at the development of DL information systems. The use of MAS in the development of modern applications in the field of DL is convenient for implementing various intellectual approaches.

Various agent platforms (AP) are used to create the multi-agent environment of the DL. The most known platforms are: JADE (Java Agent Development Framework), Jack Intelligent Agents, MadKIT (Multi-Agent Development Kit), AgentBuilder, Cougaar (Cognitive Agent Architecture), MASON (Multi-Agent Simulator of Neighborhoods), CogniTAO, Adaptive Modeler and etc. One of the most widely used programming environments for developing MAS is JADE, written on Java language [20]. The basis of this system is the software environment, without which the existence of agents is impossible. Inside the environment there are formed containers in which agents function. After the startup, each agent must transfer data about himself to one of the containers in order to register in the system. Next, the software environment will monitor the operation of the entire system and, if necessary, make the required control actions on individual agents. Agents exchange information among A number of publications are de-

voted to the development of intelligent DL systems. Multi-agent personalized learning systems are widely used, which are aimed at creation of individual trajectories of learning, taking into account the individual characteristics of the student. In work [8] there was proposed an intellectual system of learning on the basis of APLe (Agents for Personalized Learning), which allows to conduct learning taking into account the preferences of the student. Multi-agent systems are widely used in smart-learning systems, at the development of which a set of agents with the necessary functions is created [9]. In order to ensure the creation of an individual trajectory of learning taking into account the intellectual and psychophysical characteristics of students in DL there are applied the MAS on the basis of cognitive and ontological approaches [10, 11]. Ontological models (OM) are usually created using standard LOM metadata (Learning Object Metadata), which have a hierarchical structure [12]. Such models allow to systematize the teaching material and contribute to the formation of its optimal structure. The article [13] describes agents created on the basis of the ontological approach, which serve as assistants in the choice of the study material. The multi-agent system helps the student to select the material necessary for him to learn on the basis of the data collection and processing using ontological models.

The following structure of the article is proposed: the second chapter shows the statement of the problem of the research. The third chapter is devoted to the development of agents of the Smart-system of DL PIV. In the fourth chapter, an ontological model of the information system is constructed. The fifth chapter presents the results of the OWL model in the Protege ontology editor. At the end of the article there is given a conclusion and a list of used literature.

2. Statement of the problem

The statement of the problem is formulated as follows: it is necessary to develop the OWL model of a multi-agent Smart-System of Distance Learning for people with visual disabilities, in order to optimize the learning process and to obtain high-quality engineering education in a shared laboratory using modern equipment.

Let's introduce the following definition: as shared laboratories there are considered any laboratory that has a complete infrastructure (modern equipment, hardware and software) for distance learning and to obtain a quality engineering education for people with visual disabilities.

To achieve this aim it is necessary to solve the following tasks:

– to create and to define agents' functions for multi-agent Smart-system of DL PIV creation in JADE;

– to create an OWL model of information system for implementing the system and agent-based approaches.

3. Development of the agents of the Smart-system of DL PIV

At the development of multi-agent DL smart-systems the use of various agents is relevant on the basis of the use of cognitive, ontological, statistical and intellectual approaches.

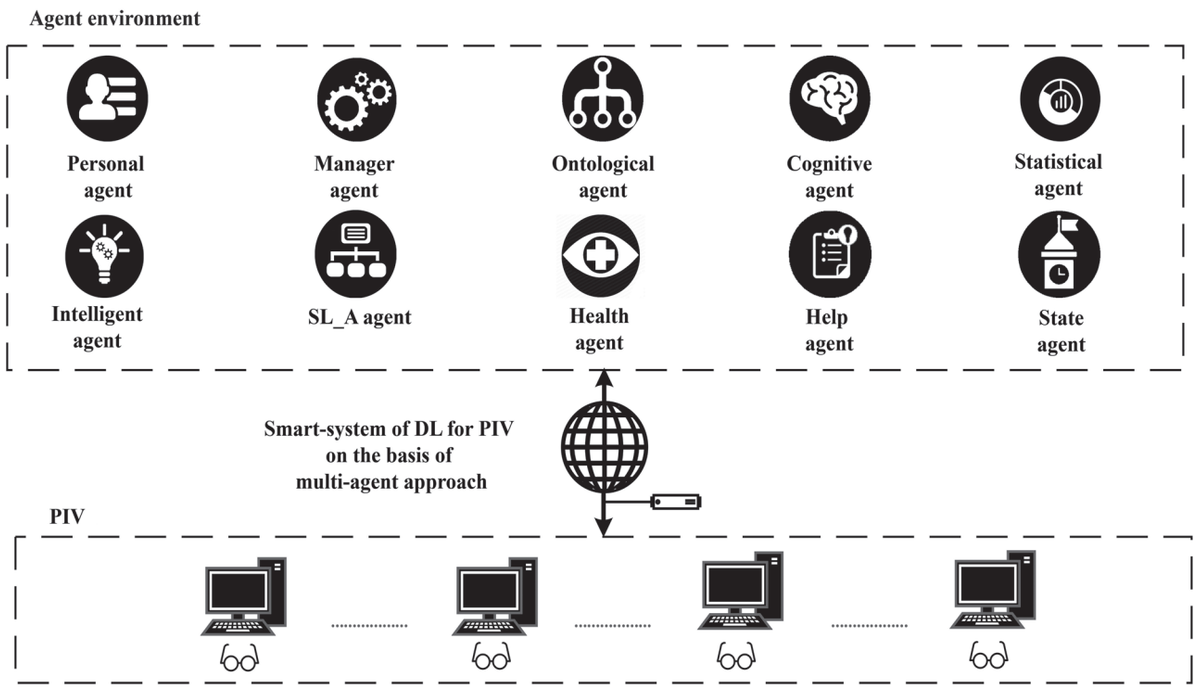

Fig. 1. Structural diagram of multi-agent smart-system of DL for PIV in JADE

During the designing of DL multi-agent system, the following agents are created: personal, cognitive, ontological, statistical, intellectual, support and decision-making, manager, health, shared laboratories and state agent. The structural diagram of the multi-agent smart-system of DL PIV, which consists of the created agents, is shown in Figure 1.

Each agent in the DL smart-system performs a specific function:

– the personal agent (PA) registers personal data, collects individual characteristics (attributes) of PIV and chooses the trajectory of PIV learning with regard to visual defects, and also selects the necessary educational material;

– the manager agent (MA) monitors the flow of messages from other agents in order to correlate them correctly;

– the ontological agent (OA) constructs the OWL model of PIV, and also structures the input and output data of the system;

– the cognitive agent (CA) is designed to identify the level of perception of information by PIV ay myopia, hypermetropia, with deep and moderate visual impairment, as well as the implementation of cognitive learning techniques;

– the statistical agent (AS) takes into account the dynamics of DL users, records the logs of events, system errors, and provides with the identification of informative features of PIV based on factor analysis;

– the intelligent agent (IA) determines the level of learning based on fuzzy logic and predicts the results of PIV learning with the help of neuro-fuzzy logic;

– the shared laboratory agent (SL_A) connects PIV to SL_A and gives an access to modern equipment;

– the health agent (HA) provides a complex of therapeutic gymnastics for the eyes and offers an individual mode of work on the computer, taking into account the features of vision;

Table 1

Description of the agents of MAS DL for PIV

Agent	Denomination	Description
Personal agent	OM_{PA}	1. Registration or authorization of the user in the smart-system of DL for PIV. 2. Download the profile with the current user's learning trajectory. 3. Creation of the trajectory of user's learning trajectory. 4. Forming the learning interface. 5. Loading the processed information into a database and knowledge base. 6. Activating the container 2. 7. Operation in a software environment.
Manager agent	OM_{MA}	1. Establishing communication with agents. 2. Performing an asynchronous transfer of messages from other agents. 3. Implementation of the information submission regime. 4. Coordination of the work of agents. 5. Activating the container 1. 6. Operation in the software environment.
Ontological agent	OM_{OA}	1. Forming of OM of PIV. 2. Forming of OM of learning. 3. Forming of OM of SL. 4. Activating the container №2. 5. Selection of the learning class. 6. Activating the container №5. 7. Selection of the course. 8. Interactive elements of the course. 9. Activating the container №3. 10. Operation in the software environment.
Cognitive agent	OM_{CA}	1. Distinguishing of psycho-physiological signs of PIV based on the questionnaire: – test of Eysenck; – Amthauer test; – special tables for determining visual acuity and defects. 2. Formation of the information perception environment. 3. Submission of learning information from the monitor screen: – myopia mode; – hypermetropia; – with deep and moderate visual impairment; – normal vision mode. 4. Choice of color schemes: – selection of a background of pale yellow, pale green for myopia mode; – selection of the background of bright yellow, bright orange color for hypermetropia regime; – selection of a background of white text and black background for mode with deep and moderate visual impairment; – normal vision mode. 5. Location of the learning information: – in the upper left part of the screen at myopia; – in the right lower part of the screen at hypermetropia. 6. Sound. 7. Preferred time of day for better information assimilation. 8. Activating the container №2. 9. Loading the processed information into the database. 10. Operation in the software environment.

– the help agent (AH) by the prompts and messages helps students to choose teaching materials;

– the state agent (SA) connects the smart-system of DL for PIV with government agencies, provides legal information to users and access to the regulatory database.

Agents operate in a software environment that is constantly changing under the influence of the activity of PIV in the system. To program the configuration of the created agents there is used an environment that includes the classes and libraries of JADE platform. There were created 5 containers in which the relevant agents are placed: container 1 (MA), container 2 (PA, CA, IA), container 3 (AS, OA), container 4 (HA, AH), container 5 (SL_A, SA).

4. Creation of owl model of multi-agent smart-system of dl for PIV

In order to solve the problem there was developed an ontological model of multi-agent smart-system of DL for PIV in the form of the following map:

OMMAS_DL_PIV =
< OMPA, OMMA, OMOA,
OMCA, OMAS, OMIA,
OMSL_A, OMHA, OMAH,
OMSA>,

where

OMPA – ontological model of PA;

OMMA – ontological model of MA;

OMOA – ontological model of OA;

OMCA – ontological model of CA;

OMAS – ontological model of AS;

OMIA – ontological model of IA;

OMSL_A – ontological model of SL_A;

OMHA – ontological model of HA;

OMAH – ontological model of AH;

OMSA – ontological model of SA.

Agent	Denomination	Description
Statistical agent	OM_{AS}	1. Processing of multidimensional data. 2. Distiguishing of informative features of PIV and factor analysis of data. 3. Collection of statistical data of the surveyed learning materials for a certain period of time. 4. Information about system errors. 5. Loading of the received information into the data and knowledge base. 6. Activating the container 3. Operation in the software environment.
Intellectual agent	OM_{IA}	1. Determination of the knowledge level of PIV. 2. Data forecasting based on neural-fuzzy logic. 3. Issuance of the certificate of completion of the course or its redirection to re-training. 4. Loading of the received information into the data and knowledge base. Activating the container 2.
Shared laboratories agent	OM_{SL_A}	1. Providing access to the SL. 2. Modern equipment: – Computing cluster; – laboratory with industrial equipment. 3. Creation of a virtual machine. 4. Installing of software (SW) and receiving tasks. 5. Calculations. 6. Programming of Logic Controllers. 7. Checking and debugging of the created software for PIV with the teacher and without him. 8. Obtaining simulation results. 9. Access and work with real equipment. 10. Activating the container № 5. 11. Loading of the received information into the database. 12. Operation in the software environment.
Health agent	OM_{HA}	1. Determining of the learning mode in time for various diseases. 2. Selection of a set of exercises for myopia. 3. Selection of a set of exercises for hypermetropia. 4. Selection of a set of exercises for deep and moderate visual impairment. 5. Activating the container № 4. Operation in the software environment.
Help agent	OM_{AH}	1. Determination of the current learning page. 2. Forming hints on the learning page and issuance of hints on request. 3. Activating the container 4. Operation in the software environment.
State agent	OM_{SA}	1. Organization of access to the knowledge base of universities: – el. libraries; – catalogs; – intellectual elements of the course. 2. Organization of access to the legal database: laws; acts; regulations. 3. Organization of access to websites of state institutions: – site of the Ministry of Education and Science of the Republic of Kazakhstan; – CCSES MES website; – e-mail of the Government of the Republic of Kazakhstan. 4. Activating the container № 5. 5. Operation in the software environment.

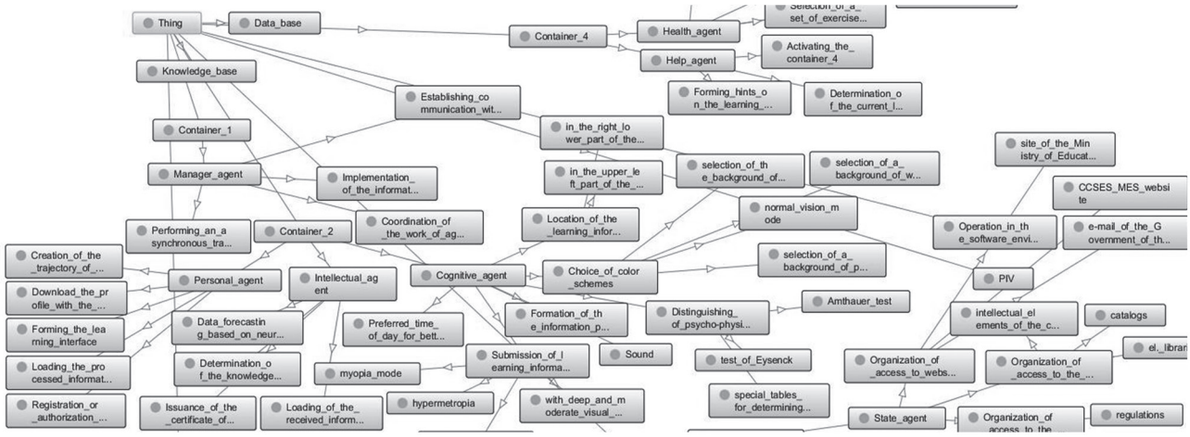

Fig.2. A fragment of a graphical representation of the OWL model of the multi-agent smart-system of DL for PIV

Table 1 describes the created agents.

On the basis of research in the ontology editor Protégé was constructed the combined OWL model of Smart-system of DL visually impaired people.

5. Representation of the owl model in the ontology editor PROTÉGÉ

There are many special tools for ontology visualization. One of the convenient editors for representing the OWL model is Protégé.

Next in Fig. 2 there is a fragment of the graphical representation of the ontological model of the multi-agent smart-system of DL for PIV using the OntoGraf tool in Protégé. This information system is presented in the form of a graph, the nodes of which represent concepts (objects or concepts), and directed relations arcs (links) which allow us to examine in detail the subject area of distance learning of PIV.

The OWL model allows for a systematic approach to construction Smart - systems based on methods of artificial intelligence and cognitive approach and helps to create effective individual process of learning visually impaired people.

6. Conclusion

The conducted researches and numerous publications on this question demonstrate the relevance of development of Smart-systems of DL based on intellectual approaches for visually impaired people, including with visual impairments.

The proposed structural diagram of the multi-agent Smart-system of DL for PIV and created on its basis the OWL model allow structuring the input and output data, facilitates the writing of Software, selecting of Hardware, and contributes to the qualitative engineering education of PIV.

Therefore, the dignity of using the developed by OWL model of a specialized Smart-system of DL for PIV based on multifunctional agents is:

– an integrated approach based on the use of various intellectual, cognitive and statistical methods;

– development of an individual trajectory of learning of PIV taking into account psychophysiological features of information perception;

– submission and positioning of information on the monitor screen, depending on the features of the vision.

Determination of the preferred form of information (text, graphic) on the screen at various visual defects (myopia, hypermetropia) and with residual vision;

– the choice of color schemes, best for people with various eye diseases;

– distance learning of PIV of the newest equipment in the SL;

– multifunctionality, stability to system errors and high self-organization of components (agents)of MAS, created with the help of modern multi-agent platform JADE, and also optimization of computing resources.

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