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W O R K S H O P
P R O C E E D I N G S

MODELING OF AGRICULTURAL PRODUCTS DURING ADVERSE EVENTS

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Agricultural production in different regions of the country is strongly influenced by hydrometeorological factors. These factors largely determine the final results of commodity producers. The Irkutsk region, whose territory is characterized by a sharply continental climate, is no exception. Almost every year, organizations and peasant (farm) enterprises lose part of their production volumes. Therefore, it is necessary to take into account possible damage when planning. Models for optimizing agricultural production to determine planned indicators under risk conditions are proposed.

These models are based on a problem of parametric programming. This is explained by the fact that many characteristics are dependent on the parameter in the form of time and the previous value. In other words, the problem of producing agricultural products for the case of transition of the values of characteristics of the model into unfavorable events was solved.

Since the time series of production and economic characteristics of the model can be described by trends to assess adverse events, an algorithm for their identification was used based on the construction of multi-level trends (Ivanyo Ya.M., Petrova S.A., 2022) according to the idea about of the hierarchical structure of the time series (Druzhinin I.P., Smaga V.R., Shevnin A.N., 1991). When using this algorithm, adverse events are isolating from the original series. To do this, a sequence of local minima form from the original series, a trend constructed, and levels located below this trend identify. The assessment of the probabilities of these events is determined by the distribution law, which describes a number of differences in actual data and trend values of a sequence of local minima. In the absence of trends and considering a series of characteristics in the form of random variables, statistical and physical criteria are applicable to identify unfavorable events (Krenke A.N. et al., 1995). Of the received adverse events, the smallest of them are determined according to the strength of their influence on production processes.

Based on the identified events and other characteristics, the task of optimizing of production of agricultural products is formed. Solving this problem allows us to obtain optimal production volumes in accordance with maximum incomes, which correspond to the calculated probability of events. A comparative analysis of planning results under average conditions and taking into account unfavorable events shows the probable losses of commodity producers on level at the enterprise and municipal district.

TESTBED-BASED APPROACH TO TESTING A LIBRARY FOR EVALUATING NETWORK RELIABILITY ALGORITHMS

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In studies of energy system resilience, system performance is mainly evaluated from a functional point of view using flow models [1]. Since the definition of energy system resilience is associated with cascading failures whose evolution depends on the system topology, it is necessary to add a system performance evaluation from a structural point of view for a comprehensive resilience research. It is proposed to combine the available methods for calculating network reliability into a library.

An instance of network reliability problem is a tuple I = (G, P), where G = (V, E) is an undirected graph. P is a function that assigns a probability to each edge of the graph G, i.e. each edge e ∈ E is operable with probability P(e) ∈ [0, 1]. The graph G is assumed to be connected. All edge failures are independent. The failure of an edge e results in the deletion of the corresponding edge from the graph G. Thus, the reliability problem on instance I is then defined as follows: A new graph Gs is probabilistically constructed such that its vertex set is V and each edge e ∈ E is included in it with probability P(e). In other words, the all-terminal reliability of the network G is the probability of that the resulting graph Gs remains connected. There are some other variants of the network reliability problem, the general one being the two-terminal instance, where one is interested if there is at least one path between two given vertices.

We have investigated some available algorithms for the network reliability and unreliability problems, focusing on their practical performance on different CPU architectures. The testing of the algorithms was implemented using a testbed represented by a system service-oriented scientific workflow in the BPEL language. The testbed is developed using the Framework for Development and Execution of Scientific WorkFlows (FDE-SWFs). FDE-SWFs is an extended version of the Orlando Tools framework [1] and is designed to create service-oriented applications developed based on workflows. The testbed includes a wide range of system libraries for testing scientific workflows, analyzing their performance based on workflow module profiling, verifying interactions with different data sources, and visualizing the analysis results. The results of a comparative analysis of running algorithms (Karger's unreliability algorithm [2] and Yeh's BAT algorithm [3]) are represented in Figure 1. Figure 1,a) shows the network reliability that is the key subject domain parameter. Figure 1,a) and 1,b) demonstrates the system evaluations of the algorithm runs. The algorithm runtimes and the number of instructions were obtained by profiling the modules that implement the algorithms under consideration.

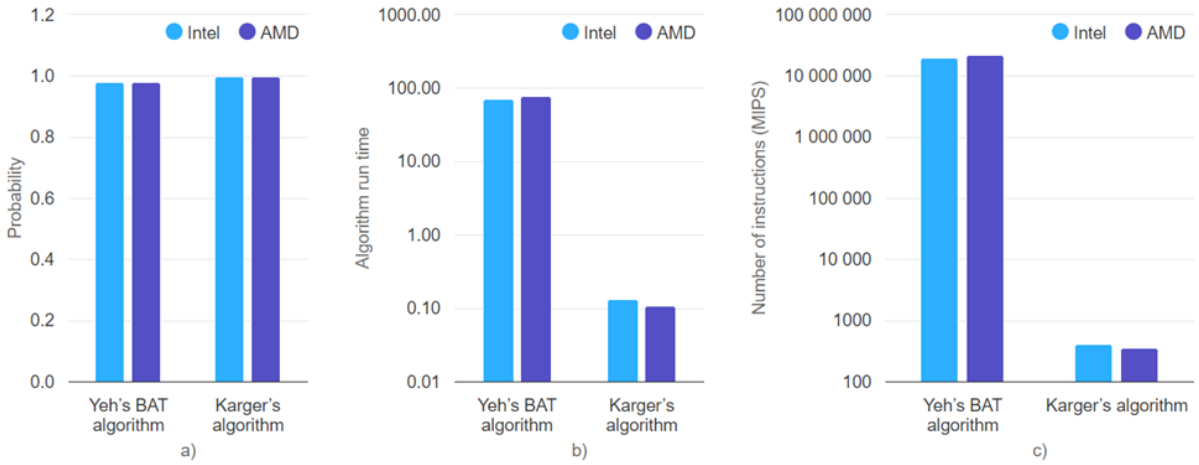

Fig. 1. Comparative analysis

Finally, we have found that Karger's algorithm is effective in real large energy networks, while Yeh's BAT algorithm becomes impractical even for small-sized graphs.

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WAYS TO INCREASE PRODUCTIVITY IN THE DEVELOPMENT OF COMPLEX INFORMATION SYSTEMS

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One of the most discussed topics in the Russian IT sector in recent years has been the shortage of personnel. According to various estimates, the shortage of specialists in various fields ranges from 500 thousand to 1 million. Obviously, it will not be possible to fill such a significant shortage of IT specialists in a short time. It is hard to believe that it will hardly be possible to cope with the deficit in the medium term given the demographic crisis and other events that have adversely affected the labor market.

In conditions of limited human resources, it is necessary to focus on increasing labor productivity. Activities in the field of information systems development can be viewed through the prism of the "black box" model of the information process for creating an information product (Fig. 1).

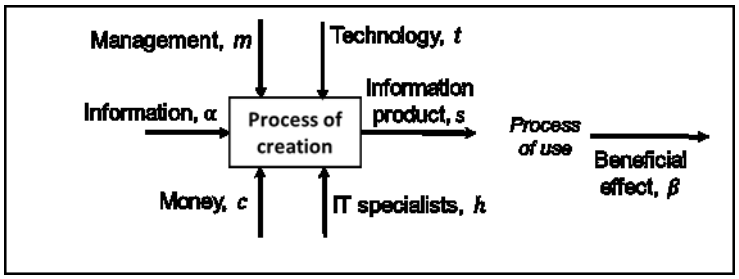

Fig. 1. Activities of specialists in creating IP

The "input" of the intellectual process of activity of IT specialists (analysts, developers, testers, etc.) is supplied with information of various contents α (description of the subject area, technical specifications, problem situation, etc.). At the "output" of this intellectual activity, we receive some information (software) product (IP), which later, when used, creates a useful effect β. The controlling influences of the activities of specialists traditionally include management (as management) m and technology t. Resources for the process of creating a software product are financial and human resources - money c and IT specialists h.

An information product (a tool for use) is an intermediate result of assessing the activities of IT specialists, and the final result of the activity is the beneficial effect of using the product, which can be measured by the productivity of the activity to create it.

The effectiveness of using an information product is determined by its quality, which depends on the effectiveness of two control influences on the creation process - the effectiveness of management and the technology for creating IP.

The effectiveness of management and the effectiveness of the technology for creating IP determine the economy of the creation process - the efficiency of the use of financial resources and the efficiency of the use of human resources.

Table 1. Methods and mechanisms for increasing efficiency

Efficiency	*Function*	*Methods and mechanisms*
Productivity	$F(\beta) \to max$	management efficiency, technology efficiency
Management efficiency	$F(m) \to max$	centralization, coordination, benchmarking, standardization, systematization, integration and etc.
Technology efficiency	$F(t) \to max$	semantic technologies [], graphic notations [], ontologies [], thesauri and etc.

Cost efficiency	$F(\mathrm{c}) \to min$	results-oriented budgeting, methodology of evaluation of budgetary IT investments and etc.
HR efficiency	$F(h) \to min$	training and retraining of personnel, scientific organization of labor, rationalization, knowledge management, motivation and culture, and etc.

Conclusion:

- The shortage of personnel in all sectors of the national economy without exception has created an acute competitive demand for competent and gifted people, for whom the IT sector is not always a priority choice;
- It is not possible to cover the shortage of IT personnel in a short time due to a number of prevailing conditions;
- It is possible to reduce the severity of the problem by increasing the efficiency of development management aimed at increasing the productivity of IT specialists;
- The main methods of increasing labor productivity are related to the management and organization of activities;
- Technology is a key enabler for improving the productivity of IT professionals, especially in complex information systems design and development environments.

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EVALUATION OF THE EFFECTIVENESS OF MEASURES TO CREATE A COMFORTABLE URBAN ENVIRONMENT BASED ON NEURAL NETWORK MODELS

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Annotation. At the moment, Russia is implementing the national project "Housing and Urban Environment". Within the framework of the Project, the government of the Russian Federation has determined an exhaustive list of measures aimed at improving the comfort of the urban environment. To assess their effectiveness, the Ministry of Construction of Russia has developed and approved a methodology for the formation of an index of the quality of the urban environment. The paper proposes an alternative method for evaluating activities aimed at improving the comfort of the urban environment, using neural network models of natural language.

Introduction. The index method for assessing the comfort of the urban environment, proposed by the Ministry of Construction of Russia, takes into account many quantitative and measurable indicators that characterize the level of living comfort in the corresponding city [1]. One of the indicators is the level of citizens' involvement in decision-making in the field of creating a comfortable urban environment (CCUE). One of the forms of interaction between citizens on CCUE issues is electronic voting for improvement projects on a specialized site of the Ministry of Construction of Russia [2]. Studies show [3] that this method of obtaining feedback from citizens is ineffective and needs to be improved.

Additional tools for obtaining feedback from citizens can be various kinds of sociological surveys and studies [4-7]. The disadvantages of this tool include: long time intervals from asking questions to obtaining results, a narrow range of issues covered and a limited audience. In [8], the author proposed a variant of receiving feedback through a mobile application. The authors of [9] use messages from the social network Twitter as a source of feedback.

In our study, we evaluate the effectiveness of activities aimed at the CCUE (Events), through the semantic similarity between the messages of citizens on the Internet (Messages) and the descriptions of the Events.

Data and experiment. In this work, we analyze more than 74 thousand text messages and descriptions affecting the problems and solutions to FCGS issues on the territory of the Khanty-Mansiysk Autonomous Okrug-Yugra. Texts of Messages and Events are represented by two sets of datasets. Datasets are grouped by municipalities, thematic categories and month. Brief characteristics of dataset sets are given in Table 1.

Table 1. Brief characteristics of dataset sets

Dataset set	Quantity datasets	Total messages in a set
Messages	6 224	73 897
Events	108	209

The study includes three main stages:

- Stage 1. Extraction of meaningful phrases and phrases (N-grams).
- Stage 2. Translation of the obtained N-grams into vector form, taking into account the context.
- Stage 3. Determining the semantic similarity of the obtained vectors of N-grams.

To extract the most significant key N-grams from messages, it is proposed to use the TF-IDF algorithm [10]. From each dataset, 100 most significant N-grams from N = 2 to N = 4 were

extracted. The significance of each N-gram of the dataset was determined by the rank assigned to it (Rds) according to the formula (1):

$$R_{ds} = TF_{n-gramm} \times IDF_{n-gramm}, \quad (1)$$

where R_{ds} is the rank of an N-gram in the dataset, $TF_{n\text{-}gramm}$ is the frequency of an N-gram within a single message, $IDF_{n\text{-}gramm}$ is the inverse of the frequency with which an N-gram occurs in all messages in the dataset.

The total rank of each N-gram for the entire set is calculated by formula (2):

$$R_{sum} = \sum_{k=1}^{m} R\,ds_k, \quad (2)$$

where R_{sum} is the total rank of the N-gram, R_{ds} is the rank of the N-gram in the dataset.

The R_{sum} values for the TOP-20 extracted N-grams are given in Table. 2.

Table 2. Rsum values for all extracted N-grams

N value	Messages		Events	
	Max R_{sum}	**Min R_{sum}**	**Max R_{sum}**	**Min R_{sum}**
N=2	59,2314	0,0221	3,8184	0,0306
N=3	3,7017	0,0263	1,0693	0,0352
N=4	2,5768	0,0289	0,9183	0,4130

To obtain numerical vectors of the contextual representation of N-grams, a pre-trained neural network model Sentence-BERT (SBERT) is used [11]. SBERT is a modification of a pre-trained BERT network. A feature of the modification is the use of Siamese and triplet network structures to obtain semantically meaningful sentence vectors. This allows retraining the model on the task of determining semantically close texts. The model is further trained in such a way that sentences similar in meaning are encoded into vectors close in metrics, while maintaining semantic relationships between phrases. The dimension of the vector of each N-gram is 512.

To assess the semantic proximity of N-grams, the cosine distance between vectors is used, calculated by formula (3):

$$\text{similarity} = \cos(\theta) = \frac{A \cdot B}{\|A\|\|B\|} = \frac{\sum_{i=1}^{n} A_i \times B_i}{\sqrt{\sum_{i=1}^{n} (A_i)^2} \times \sqrt{\sum_{i=1}^{n} (B_i)^2}}, \quad (3)$$

where A and B are compared N-gram vectors, cos(θ) is the cosine distance.

The result of comparing the TOP-10 N-gram vectors for N=2 is presented in table. 3.

Table 3. Cosine distance for TOP-10 N-gram vectors

	children's playground	improvement object	sports ground	walking area	house	recreation area	public improvement	children's play	improvement year	small architectural
children's playground	**1,000**	0,312	**0,545**	**0,574**	0,373	**0,551**	0,327	0,751	0,357	0,305
crosswalk	0,373	0,273	0,365	0,688	0,303	0,342	0,317	0,271	0,318	0,208
hot water	0,257	0,214	0,284	0,256	0,255	0,275	0,190	0,257	0,292	0,192
roadway	**0,513**	0,459	0,417	**0,624**	0,460	**0,586**	0,416	0,398	**0,504**	0,286
garbage	0,335	0,350	0,297	0,373	0,351	0,376	0,314	0,305	0,376	0,203

removal										
trash can	0,338	0,305	0,280	0,354	0,333	0,307	0,272	0,339	0,352	0,260
snow removal	0,271	0,185	0,247	0,293	0,256	0,253	0,178	0,246	0,267	0,157
road repair	0,279	0,235	0,227	0,424	0,290	0,325	0,272	0,243	0,308	0,279
walking path	0,384	0,264	0,366	**0,741**	0,334	0,304	0,305	0,296	0,324	0,208
heap of snow	0,286	0,176	0,257	0,292	0,298	0,227	0,139	0,303	0,286	0,162

Conclusions. The result of the presented study was a set of N-grams extracted from text messages of citizens and the media, on the basis of which an assessment of the effectiveness of the Activities was given. The evaluation was based on a comparison of the semantic similarity between Message N-grams and Event N-grams. This assessment revealed a significant discrepancy between the expectations of citizens presented in the Messages and the Activities carried out by local authorities.

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THE USE OF THE SEMANTIC APPROACH TO AID CONCEPTUAL REPRESENTATION OF MATHEMATICAL MODELS

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The Melentiev ESI SB RAS has been developing an ontological knowledge portal. One of its integral parts is building ontologies for different research fields of the energy studies domain [1]. Semantic technologies are among emerging trends in knowledge formalization. Their use in research enhances the possibilities for structuring information, exchanging data between processes, applications, experts, and acquiring new knowledge. Ontological models as a way of semantic modeling allow for visually compelling representations of domain-specific entities and enable the transition from working with data to working with knowledge [2].

This paper seeks to use ontological representation to visualize the knowledge incorporated in mathematical models by researchers. A mathematical model is an equivalent of the object or process under study and captures in mathematical terms (i.e., equations) the key properties and relationships between its components. A mathematical model when presented as an ontology (semantic model) will provide a structural and more transparent representation of the objects and relationships described by it, which will enable experts in different domains to better understand each other and share their knowledge.

We use the MISS-EL model as the object of such a transformation. MISS-EL is a stochastic optimization model of electric power industry expansion planning, implemented in Excel with use of Visual Basic. [3]. The model is designed for a broad assessment of the competitiveness of different power plants to serve a given electricity demand. The optimality criterion is the minimum cost of power generation and transmission.

$$F = \sum_{j} \sum_{e} R_{ej} X_{ej} \rightarrow \min$$

where R_{ej} is the cost of electricity generation (discounted cost, rubles),

X_{ej} is the volume of electricity production (kWh).

Ontological modeling starts with the analysis of terms. The basic terminology used in the investigated mathematical model matches the input data and the data used in the computation, which serve as the basic concepts of the ontology. In particular, the calculation of the cost price of electricity generation takes into account the following:

C_e - cost of fuel e supplied to power plant j (gas, coal)

B_{ej} - unit consumption of fuel e for electric power generation at plant j

H_{ej} - number of hours of utilization of plant j for electric power generation fired by fuel e,

K_{ej} - unit capital expenditures incurred on capacity additions for electric power generation fired by fuel e at plant j,

D - unit CO_2 emissions when running on fuel e

P - penalty for CO_2 emissions

In addition to the above components, the calculations factor in the amount of possible exports or required imports of electricity so as to balance out the electricity demand and generation gap. The ultimate goal of the calculations is to optimize the power generation mix. The figure below presents the ontology of the mathematical model for electric power industry expansion planning MISS-EL. The figure elucidates the relationships between the basic concepts that match the data used by the model.

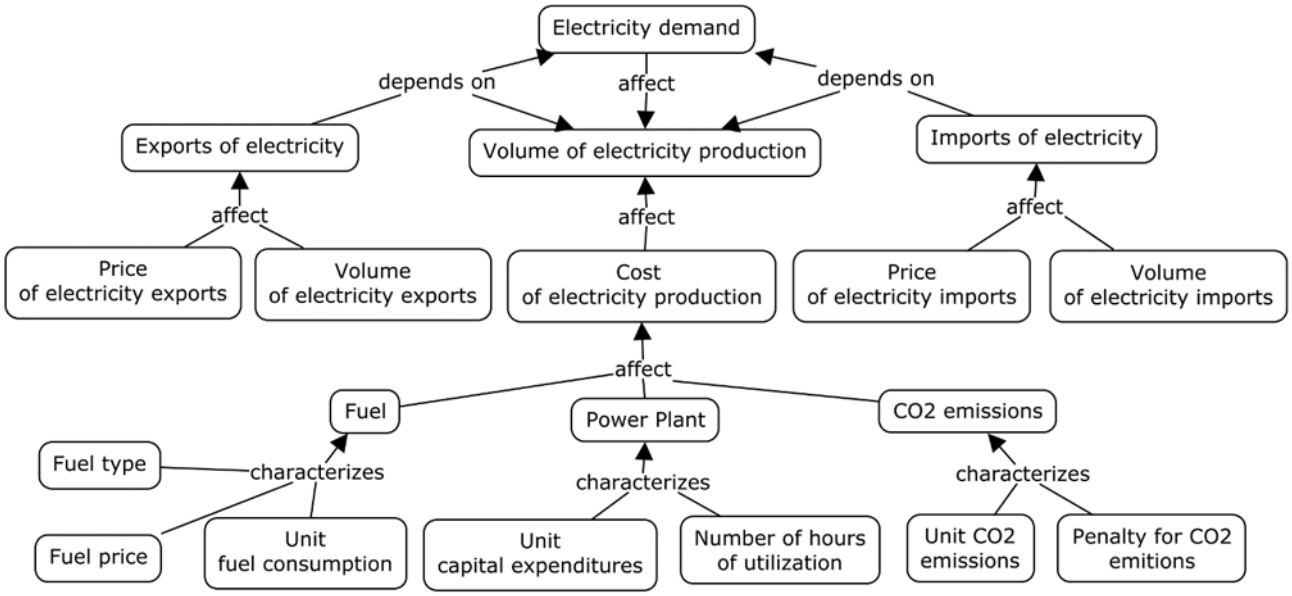

Fig. 1. The ontology of the MISS-EL mathematical model

The graphical representation of ontologies visualizes the dictionary of terms of the corresponding research area along with the relationships between individual concepts, streamlines them and proves instrumental in reconciling definitional issues between experts in different fields. When reinterpreted in such a way, research problems lend themselves to the transfer of knowledge in a more accessible form while increasing research productivity and facilitating higher quality research by experts.

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APPROXIMATION TECHNOLOGY OF MULTIDIMENSIONAL TIME SERIES USING NONLINEAR DYNAMIC MODELS ON THE PLANE

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Multidimensional analysis of time series data is one of the most popular problems in machine learning. In most works, the hypothesis of a high degree of interdependence of measured and digitized trajectories is implicitly applied, which makes it possible to decompose the problem into a set of one-dimensional problems. The problem in analysis of multidimensional time series is very complicated, which makes the task of developing new approaches and algorithms very relevant for it.

The report discusses a set of algorithmic approaches implemented in the form of software technologies aimed at equipping dynamic systems that can serve as models for interconnected time series. Currently, the library of model templates includes a piecewise linear approximator, a spline approximator, a template based on the technique of the quadratic Bezier curve, approximators based on the standard Shepard operator and on the self-learning Shepard operator (see, for example, [1]). As a complement to all these model patterns, a fractional rational approximator is implemented, including, as a special case, a technology based on the Pade method. The structure of all implemented models includes sets of template parameters that allow training on specific samples, as well as safety fields that work with the likely exit of queries beyond the predefined ranges.

The proposed technology is based on the construction of dynamic systems that include the above-mentioned template components in the right parts, the addition of discrete series to continuous ones using spline techniques, the formulation of functional residuals penalizing deviation of models from reference and/or experimental trajectories and solving learning problems (parametric identification). Functionals constructed in this way are usually nonconvex, which requires the use of globalized optimization technologies.

The efficiency of the proposed tools was tested on nonlinear two-dimensional test problems with well-known trajectories of dynamical systems and with using software for automatic identification of dynamic objects by the systems of differential equations [2]. For considerable problems it was possible to construct good approximations of the time series. The results of the carried out computational experiments are presented.

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MONITORING DATA ABOUT AGRICULTURAL PRODUCTION FOR SIMULATION OF MANAGEMENT DECISIONS

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Digital technologies make it possible to obtain information about the activities of various aspects of an agricultural producer. Typically, in the absence of automated systems for monitoring field data at the stages of soil cultivation, sowing, plant care, harvesting, storage and preparation of seed material and technical means for a new cycle of work, planning and forecasting production indicators was carried out on the basis of accounting and financial reporting.

Now it is possible to obtain information from fields, farms, satellite maps and unmanned aerial vehicles, as well as automated agrometeorological stations, which contributes to the generation of a large volume of data. This, in turn, allows us to detail the processes of obtaining agricultural products, expanding the possibilities of modeling various aspects of the producer's activities.

The development of a data monitoring system using precision farming methods, the use of satellite information and automated agrometeorological sites helps expand the possibilities of using mathematical programming problems to optimize the production of agricultural products. In particular, detailed information about the mechanical, chemical, biological state of the fields of an agricultural organization or peasant (farm) enterprise will make it possible to use optimization models that characterize the heterogeneity of agricultural land and differentiate fields by production.

In addition to this, the accuracy of forecasting production and economic indicators increases, both general, characterizing the work of the organization, and specific, describing the capabilities of specific fields, farms, types of crop and livestock products.

Data monitoring systems on the state of fields contribute to obtaining information on the results of the impact of extreme hydrometeorological, technogenic and biological events on plant development and yield. At the same time, the obtained agrometeorological data better reflects the conditions for growing products than information from a meteorological station located at a considerable distance from the agricultural land of the producer.

A data monitoring project has been developed for the educational research and production site of the Irkutsk State Agricultural University.

APPROACHES TO ANALYSING THE FLOWS OF SCIENCE AND TECHNOLOGY KNOWLEDGE AND THEIR APPLICATIONS IN ENERGY

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The distribution and transfer of knowledge is the basis for scientific and technological progress and expected innovations. One of the ways to analyze trends and forecast scientific and technological development is to track the dynamics of knowledge flows in a certain subject area [1]. The concept of knowledge flows can be particularly important for identifying actively developing scientific and technological trends and identifying likely areas of future advancements [2]. Complex analysis of the network structures of documents, as objects of codified knowledge, built on the basis of bibliographic citation and their semantic proximity, can give us the measuring the degree of force and changes in relationships between the fields of science and technological knowledge over a period of time [3]. Such an analysis can reveal the invisible mechanisms of knowledge transformation, its assimilation, diffusion and evolution of the subject area under consideration as a whole.

The report provides a review of the current state of approaches to the analysis of scientific and technological knowledge flows with an emphasis on use in the energy sector. An assessment was made of the applicability of the results of such analysis and its prospects for the problems of scientific forecasting of energy development. Particular attention is paid to the analysis of semantic flows of knowledge as the basis for identifying key trends in the subject area of energy and building predictive models on this basis. The place of the map of scientific and technological knowledge flows in building an ecosystem of knowledge in the field of energy is also shown.

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CONSTRUCTION OF COVERINGS OF SURFACES OF REVOLUTION WITH GEODESIC CIRCLES

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The problem of constructing minimal (the thinnest) coverings, along with the densest packing problem, is the classical problem of computational geometry. It arises in applications such as wireless sensor location and global navigation and communication systems design. In this case, the surface to be covered is often a surface of revolution, and the covering elements are the same. This paper considers the problem of constructing the thinnest coverings of such surfaces with a given number of equal geodesic circles.

Let we are given a metric space X and the surface of revolution $S(x,y,z) \subset X$ in paramertic form $x = x(\alpha,u), y = y(\alpha,u), z = z(\alpha,u) : \alpha \in [0,2\pi]; u \in (-\infty;+\infty)$.

It is necessary to place n equal balls $C_i(O_i,R)$ with centers $O_i(x_i,y_i,z_i) \in S$ so that the surface S belongs to their union and the balls' radius is minimal. The intersection of a ball with the surface under consideration is called 'geodesic circle'. Then the problem can be written as

$$R \to \min,$$
$$\forall p \in S, \exists i : \rho(O_i,p) \le R,$$
$$O_i \in S, i = \overline{1,n}.$$

Let us highlight that $\rho(a,b)$ specifies the distance between two points in the space X and is determined from the solution of the following optimization problem:

$$\rho(a,b) = \min_{\Gamma \in G(a,b)} \int_{\Gamma} \frac{d\Gamma}{f(x,y,z)}.$$

If a continuous function $f(x,y,z)$ is interpreted as an instantaneous speed of movement, then $\rho(a,b)$ is the minimum time of movement between points $a,b \in S$.

To solve the problem, we propose a heuristic algorithm, based on the construction of a geodesic Voronoi diagram and an optical-geometric approach, which allows one to find locally optimal solutions. We consider a sphere, a spherical segment, a cylinder, and a cone as the surface to be covered. In this case, both Euclidean and non-Euclidean metrics are used.

Additionally, we carry out statistical analysis of the results of the computational experiment. The deviation of the radius from the best found one is considered as a random variable. It turned out that it obeys the gamma distribution, and for different surfaces the parameters are very close. Testing the hypotheses using the Pearson and Kolmogorov-Smirnov criteria shows that at the level of significance 0.05, there is no reason to reject them.

MEGALOPOLIS PASSENGER TRANSPORT HUB MODEL IN THE FORM OF A QUEUING NETWORK

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A passenger transport hub (further hub) is a place where passengers can transfer between different modes of transport and directions in comfortable conditions [1]. Figure 1 shows a general scheme of the hub, where M is the metro, B is a bus stop, P is pedestrian flow, C is parking, and R is a railway station.

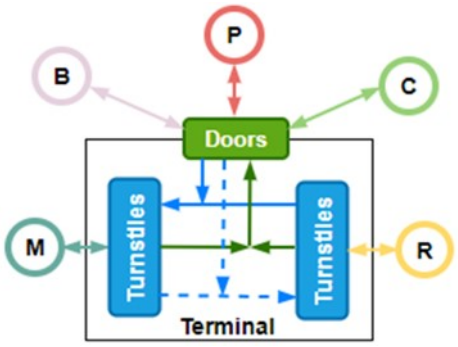

Fig. 1. General scheme of a hub

As a rule, passengers arrive at the hub and depart from it randomly, and transfer duration depends on various factors [1]. The mathematical apparatus of queuing theory is a traditional tool for modeling such systems. In this case, the most appropriate model takes the form of a queueing network (QN), which is a set of N queueing systems (hereafter referred to as nodes), where requests are transferred between nodes with specified probabilities [2]. The system may have several routes, and the request will randomly select one of them. Additionally, QN receives requests from various external sources, which may have different arrival intensities of request groups and distribution of their sizes. Nodes also vary in the number of channels, queue length, and service time.

The hub operation model is designed in three stages. Firstly, we describe the arrival of passengers using several request flows. Their number corresponds to the number of transport modes, which are separate request sources. Secondly, the operation of doors, turnstiles, elevators, and ticket offices (limiting elements) is modeled in the form of QN nodes. Finally, we consider the passenger routes within the system and other features. In particular, we take into account temporary passenger stops caused by stair or platform overflow.

Using this approach, we describe and simulate two operating hubs in Moscow and Hanoi, Vietnam, which have significant differences in the structure of their passenger flows. We estimate the maximum capacity for these systems through numerical modeling and make recommendations for improving their efficiency. The report will provide more detail on the model approach, constructed models, and investigation results.

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APPLYING THE PRINCIPLES OF TAXONOMY TO THE SPECIFICATION OF CYBER ATTACKS AND THEIR IMPACT ON SMART GRID MANAGEMENT SYSTEMS

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Modern EPS implementing Smart Grid (SG) technology are complex cyber-physical systems (CPS) consisting of two closely integrated subsystems – physical and cybernetic (information) – and a communication environment providing information exchange between them. A necessary condition for the introduction of SG technology is the availability of hierarchical centralized and distributed systems of operational and emergency management, provided with sufficient information about the current state of the electrical network and its elements. Compared with traditional networks, Smart Grids have various advantages, but, at the same time, they have difficulties in transmitting and processing large volumes of data and vulnerabilities to cyber attacks due to dependence on the data collection and exchange data platforms used [1].

Targeted cyberattacks on information and communication components of SG can lead to distortion or deletion of critical technological data, complicate real-time management operations, lead to failures in the SG physical subsystem and significant economic and social losses. Over the past few years, the number of cyberattacks affecting energy management systems has increased dramatically [2-5, etc.]. This indicates a growing need to understand the models of cyberattacks and their consequences.

To specify cyber attacks and their impact on Smart Grid management systems, we will use the principles of taxonomy. Taxonomy is the science of classifying and systematizing complexly organized areas of reality or systems that usually have a hierarchical structure. Firstly, a term “Taxonomy” was proposed by the botanist Augustin Pyramus Decandol in 1813. In the 20th century the principles of taxonomy were applied by Bloom [6] in the field of pedagogy to classify educational and tutorial goals by levels of complexity and specificity. Later taxonomy found application in various complex systems and fields of activity, including in power energy (green energy). For example, taxonomy for the classification of SG architecture samples [7]; cyber attacks taxonomy of attack strategies and countermeasures on intelligent networks [8]; also taxonomy, where nineteen models of different attack on the main operating units and control systems are classified into four groups: control of stationary mode, control of transient and auxiliary services, substation control and load management [9].

Taxonomy produces the form of a tree structure or pyramid, the formation of which begins at the lower level. To create a taxonomy of cyber attacks affecting Smart Grid management functions, data transfer attacks must be placed at the lower level, which are defined as the introduction, modification, blocking, deletion, modification of data or a combination of any of the above in devices or communication network channels. Such attacks can include false data integrity (FDI) attacks, denial of service attacks (DoS, DDoS), Replay attacks, time synchronization attacks, as well as coordinated attacks launched using malware, viruses, means of bribing personnel, fraudulent emails and social engineering [10].

At the next level, it is necessary to consider the possible consequences of these cyber attacks on the components of the information and communication structure and analyze which management functions and to what extent these consequences affect. At the highest level, it is necessary to show which of the disrupted control functions can lead to emergency conditions in the Smart Grid, the cascading development of an accident up to a blackout.

The taxonomy of cyber attacks illustrates the relationship between physical components and cyber components controlling the physical subsystem, shows which of the considered cyber attacks aimed at falsifying data can lead to incorrect operator decisions, increasing the likelihood of cascading failures. Thus, the attack taxonomy provides a structured approach to help researchers, operators, and cybersecurity professionals understand existing cyber threats and their consequences faced by modern power systems.

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DYNAMIC COGNITIVE MODELLING AS A TOOL FOR ANALYSING DEVELOPMENT FACTORS IN ENERGY

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An overview of the current state in the field of dynamic cognitive (system) modeling and relevant software and computing tools for the analysis of heterogeneous factors that influence the development of complex poorly formalized systems in the energy sector is presented, including a review of existing dynamic cognitive modeling software developed by the Melentiev Energy Systems Institute SB RAS and other institutes [1] . In addition, it examines current approaches to analyzing multi-factor dynamic systems [2], and considers modern simulation modeling tools for qualitative analysis of such systems. The article gives an idea about approaches to dynamic cognitive modeling in the context of its application for analysis of influence of complex factors and assessment of system effects on the scientific and technological development in the energy sector [3]. The results of the study can be used both for the further development of software and computing tools of dynamic cognitive modeling, and for improving the approach to the analysis of heterogeneous factors that influence development in the energy sector as a whole.

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DC-BASED SMART GRIDS

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In the modern world of power engineering, the need to improve the efficiency of power supply systems is rapidly growing. One of the promising trends in this area is the implementation of Smart Grid based on DC networks. Smart Grid is an innovative control system that combines advanced technologies to optimise power distribution and consumption processes.

The relevance of the study of improving the efficiency of power supply systems using Smart Grid based on DC networks is due to the need to ensure sustainable and reliable energy development. It also helps in reducing energy losses, improving energy efficiency and integrating renewable energy sources.

The objective of this literature review is to systematise and analyse existing studies and publications in the field of improving the performance of electricity supply systems using DC grid based Smart Grid. To this end, this literature review will focus on the following points.

1. To analyse the basic principles of DC grid based Smart Grid operation.
2. To study the experience of implementation of such systems in different countries and regions.
3. Identify advantages and disadvantages of using DC networks in Smart Grid.
4. To consider the prospects for the development of this technology and possible problems that require further research.

This literature review will systematise the existing knowledge in the field of power supply efficiency and identify areas for future research and development.

One of the methods is the Resource and Energy Efficiency Assessment of the Industrial Smart DC Grid [1]. This assessment represents an essential aspect in the implementation and operation of such systems. Resource assessment involves a detailed analysis of the materials required to construct and maintain the DC-based industrial smart grid. This includes estimating the cost of equipment, cabling, components and other materials required for the efficient operation of the system. Energy efficiency assessment includes the study of methods to optimise energy consumption and reduce energy losses in the smart grid. This aspect analyses the efficiency of the energy conversion process, the use of energy saving technologies and energy management mechanisms. Assessing the performance and reliability of the industrial smart grid involves analysing the ability of the system to provide the required level of operation and ensure reliable energy transfer. In addition, this study also covers the analysis of possible failure risks and measures to prevent them. Assessing the integration and compatibility of the industrial smart grid with other systems and technologies is another important aspect. This aspect includes exploring integration with existing power systems, as well as ensuring compatibility with various devices and communication protocols.

A generalised assessment of the resources and energy efficiency of the DC-based industrial smart grid contributes to optimising system operation, increasing system efficiency, reducing maintenance costs and improving the level of supply reliability.

Today's energy challenges, such as increasing energy consumption, the pursuit of sustainable energy development and the integration of renewable energy sources, emphasise the importance of research and development in Smart Grid and Microgrid [2]. Smart Grid represents an evolution of the traditional power grid enriched with digital technologies that enable more efficient management and control of energy consumption. One of the key research areas is to analyse the advantages and disadvantages of applying DC grids in Smart Grid. This includes studying the principles of Smart Grid operation, the experience of system implementation in

different countries, the prospects of technology development and identifying possible problems. Research in this area is aimed at optimising system operation, improving the efficiency and sustainability of electricity supply.

Microgrid, on the other hand, is an independent power supply system capable of operating both autonomously and as part of a common grid. It has the flexibility and ability to integrate a variety of energy sources, including renewable energy. This improves the reliability of energy supply, reduces energy losses and increases energy efficiency. Microgrid research focuses on resource evaluation, energy efficiency, performance, reliability, integration and compatibility with other systems. Analyses of Microgrid perspectives show their potential to create sustainable and flexible energy supply systems that can adapt to changing conditions and requirements.

Overall, Smart Grid and Microgrid represent promising areas of development for the energy industry that can significantly improve the efficiency, reliability and sustainability of electricity supply systems, meeting the challenges of the modern world and contributing to the transition to a more sustainable and cleaner energy industry.

In today's world, where technology plays a key role in the management of energy systems, Smart Grid is becoming an increasingly important component of ensuring an efficient and sustainable power supply. However, along with the benefits that Smart Grid offers, there is a need to carefully analyse the cyber threats and vulnerabilities that power supply systems may face [3]. Wind turbines, as one of the key sources of renewable energy in the Smart Grid, are vulnerable to various types of cyber threats. Attackers can attempt to hack into the control systems of wind turbines, which can lead to serious consequences such as interruption of power supply or even security risks. Therefore, it is important to continuously monitor and protect wind turbine control systems from cyberattacks.

One of the main vulnerabilities of the Smart Grid is its centralised structure, which can be targeted by attackers. Inadequate protection of centralised control nodes can lead to the possibility of an attack on the entire system, causing serious problems for the energy infrastructure. To ensure Smart Grid security, it is necessary to take comprehensive measures that include data encryption, authentication, network traffic monitoring and cybersecurity training. It is also important to develop cyberattack detection and response tools to respond to threats quickly and effectively.

Analysing cyber threats and vulnerabilities in the Smart Grid, especially in the context of wind turbines, is an important aspect of ensuring the security and reliability of the power grid. Only by continuously monitoring, analysing and improving cyber defences can the Smart Grid function effectively and ensure a stable energy supply for society.

Sensor technologies based on the Internet of Things (IoT) represent an important tool in improving the reliability and quality of electricity in smart grid systems [4]. Their deployment promises to revolutionise the way energy resources are monitored and managed, ensuring the efficient operation of electricity networks.

The use of IoT sensors enables real-time data collection on equipment status, energy consumption, and potential network failures or malfunctions. This information makes it possible to react quickly to problems, prevent accidents and optimise power management processes. One of the key benefits of IoT-based sensor technologies is the ability to create smart grids that can adapt to changing conditions and needs. This opens up new perspectives for improving the reliability of power supply, reducing energy losses and increasing the energy efficiency of systems.

However, there are also challenges on the way to the full implementation of sensor technologies in smart grid systems. The issues of data security, standardisation of communication protocols, and the need to train professionals to work with new technologies require serious attention and solutions.

Thus, IoT-based sensor technologies play a key role in improving the power infrastructure, enabling more efficient and reliable operation of smart grids. Further research and development in this area can contribute to more sustainable and energy-efficient power supply systems, meeting the requirements of today's energy market.

The fault indicators used in an intelligent monitoring system represent a key element in improving the reliability of electricity distribution. These indicators are an important tool for detecting potential problem situations in the network, which allows to react quickly and prevent potential emergencies [5]. The use of fault indicators in intelligent monitoring systems allows network operators to obtain real-time information on equipment status, load levels, energy consumption and other network performance parameters. This helps identify anomalies, predict possible failures and take action to prevent problems. One of the main benefits of fault indicators is the ability to detect problems early and implement preventive measures, which helps to reduce equipment downtime and improve the overall reliability of the power system. However, in order to use fault indicators effectively, attention must be paid to analysing and interpreting the information obtained, as well as developing algorithms for automatic control and decision making based on this data. Further research and development in this area can contribute to more resilient and autonomous power management systems, meeting the requirements of today's energy market.

DC microgrids are an innovative energy concept that is becoming increasingly relevant in the context of the development of smart cities [6]. These microgrids are small autonomous systems capable of operating both separately and interacting with centralised energy networks. In today's world, where sustainable energy development is becoming increasingly important, DC microgrids offer an efficient solution to ensure a reliable and sustainable energy system in smart cities. They allow the integration of different energy sources, including renewable sources, and provide flexibility and reliability in power distribution.

One of the key advantages of DC microgrids is their ability to operate autonomously in the event of an outage from the centralised grid, which increases the reliability of power supply in case of emergencies. In addition, microgrids contribute to improving energy efficiency, reducing energy losses and reducing greenhouse gas emissions. Despite the many benefits, there are also challenges associated with the implementation of DC microgrids in smart cities. These challenges include the need for standards and regulations, cybersecurity, and the management and coordination of the various components of the system.

Developments in DC Microgrids presented in Rangarajan et al. (2023) highlight the importance of this technology as a promising paradigm for smart cities. DC Microgrids represent an innovative approach to foster sustainable and flexible energy supply systems, which is particularly relevant in the current challenges of climate change and sustainable development.

The application of DC grids to efficiently utilise solar PV systems in smart grids represents a key aspect of current research in sustainable energy. Solar energy, as one of the most affordable and clean renewable energy sources, has great potential to be integrated into smart energy supply networks, contributing to reduce carbon dioxide emissions and improve energy efficiency [7].

Summarising the literature reviews above, the use of DC grids to integrate solar PV systems into smart grids plays a key role in improving the sustainability and energy efficiency of urban infrastructure. This approach not only contributes to reducing environmental impacts, but also has the potential to provide a reliable and stable energy supply in the face of rapid urban growth and changing climatic conditions. Thus, the integration of solar PV systems into the Smart Grid via DC grids represents a promising path to creating the smart and sustainable cities of the future. The full version of this report will include conclusions and recommendations.

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RISK MANAGEMENT DURING RESEARCH IN A MEDICAL LABORATORY

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The use of information technologies in medicine has made it possible to change approaches both to the correction of human health and to the management of production processes in healthcare. It is now possible to move from eliminating already identified failures to predicting possible deviations. Modern clinical laboratory management standards contain requirements for risk control at all stages of laboratory research [1]. The laboratory must identify the possibility of a hazardous situation, implement and verify measures to reduce the likelihood of harm and its severity to an acceptable level [2]. An example of a risk that a laboratory should minimize is the production of results that have significant errors. An incorrect result can be considered an event that creates a dangerous situation for the patient, since subsequent medical decisions and actions may cause harm to the patient [2].

It is expected that the results of laboratory examinations should reflect changes in the patient's body as accurately as possible. However, in most cases, when choosing laboratory diagnostic methods, specialists strive to achieve a balance between the accuracy of the methods used and their cost. To reduce the cost of the examination, instead of directly measuring the concentration of the analyte of interest, a calculation method is used that indirectly estimates its content (see, for example, [3]).

Our task was to develop a mathematical model designed to improve the accuracy of calculating the low-density lipoprotein cholesterol fraction. To build the models, we used the results of laboratory examinations of patients whose blood serum concentrations of triglycerides and various cholesterol fractions were measured. The performance of the models was indirectly assessed by comparing the systematic and random errors in the calculations performed on these models with respect to the values measured on the analyzer. To increase the accuracy of the calculation methodology, the technology of creating static models based on the Shepard operator was used [4,5]; The quality of the resulting model was checked using the committee method.

At the first stage, to reduce the number of calculations in assessing the fundamental possibility of using the Shepard method, computational experiments were carried out on a test sample consisting of 212 observations. Based on the results of the calculations, the following relative error parameters were obtained: the arithmetic mean of the relative calculation error is 3.94% and the variance is 452.23. The average calculation error turned out to be significantly less than when using the Friedwald calculation method [3], which is used everywhere in medical laboratories. Unfortunately, these results could not be considered satisfactory, since there was significant dispersion, which was characterized by the presence of points with an excessively high error. The number of such elements is small, but their presence sharply reduced the possibility of practical applicability of the created model.

Based on the experience of previous work, it was decided to carry out the so-called. “horizontal cleaning”, which consists in the targeted removal of sample elements that contribute the most “noise”; Performing this operation before directly constructing the model allows, in some cases, to significantly increase its adequacy. The maximum number of elements removed during “cleaning” was selected from the “95% rule” (“2-sigma rule”). The model was built with the assumption that most patients exhibit common patterns and relationships, and those elements that we remove (about 5%) represent a separate group that needs to be looked at in more detail and another model created taking into account its characteristics. Analysis of the testing results

obtained on the sample under consideration makes it possible to assert that the “cleaning” procedure made it possible to significantly, by 3-4 times, reduce the arithmetic mean and the variance of the model error.

Further modeling was carried out on the full sample of 4384 observations available to us. At this stage, testing the models and implementing the procedure for “cleaning” them already required significant computing resources. In addition, the hypothesis was tested that reducing the error is possible by dividing the original sample into several specialized parts and then building models on each of them. The first option considered for this solution consisted of dividing all patients into 2 groups - men and women. For all models, their quality was tested followed by “cleaning”; 1% of the total number of elements was chosen as the “cleaning” limit - the “3-sigma rule” was used.

It has been confirmed that when performing calculations on a model built on the basis of the Shepard method, performing a “cleaning” operation of the initial sample can significantly improve the quality of the models. The hypothesis about the advisability of dividing the sample into parts and building independent models on them is also partially confirmed by a computational experiment. The inclusion of women in a separate model immediately made it possible to reduce the variance of the error by an order of magnitude. The individual model for men, in contrast, performs much worse than the women's model and the overall patient model. However, when carrying out a repeated “cleaning” procedure, it was also possible to bring its characteristics into acceptable ranges.

The created models reflecting the relationship between lipid fractions in the blood can be used as indicators of the stability of technological processes at the analytical stage of laboratory research. To do this, the laboratory information system must evaluate interrelated metabolic parameters. The correspondence of the indicators in a particular patient to the parameters of the previously created model will serve as an additional criterion for correctly performed analyzes when validating the results of the tests performed.

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INFORMATION AND COMPUTATIONAL SYSTEM WICS: CURRENT STATE AND DEVELOPMENT PLANS

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This report considers information and computational system WICS (ICS WICS) developed for energy objects impact assessment on environment and decision-making support for reducing their harmful effects. Current functionality is shown such as: calculation of emissions of pollutants from energy objects, calculation of pollutants spreading in the atmospheric air, work with the snow measurements, visualization of results in table view and with help of geovisualization, decision-making support system for reducing energy objects' negative impact [1].

Report also considers directions of further development that includes:

- addition of new regulatory methods for work with the following pollutants: benzo(a)pyrene, arsenic, etc., and for conducting other research related to negative impact of pollutants from other kinds of objects;
- development of an external API for integration in IT-infrastructure [2] and Inventory of methods for the purpose of their subsequent unification;
- refactoring of the existing codebase.

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COLLISION-FREE PATH PLANNING IN DYNAMIC ENVIRONMENTS USING THE OPTICAL-GEOMETRIC APPROACH

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Current developments in production engineering are driven by the demand for a high degree of individualization of consumer products. For transportation of small parts, the usage of unmanned aerial vehicles (UAVs) is currently widely studied. In contrast to fixed ground- and line-bound transportation devices, UAVs requires solving a dynamic and time-variant path-planning problem. Such a problem can be solved only while considering the environment's current state [1]. The entire range of emerging problems can be divided into two classes: routing on a graph and infinite-dimensional routing. The first class includes the traveling salesperson problem and its generalizations [2, 3]. The second class deals with determining air or sea routes, and land routes with an infinite number of admissible trajectories [4]. These problems belong to the class of NP-hard problems.

We consider the problem in an environment with dynamically changing properties. The central feature of the path-planning algorithm capable of adjusting collision-free paths. We use the optical-geometric approach [5], based on the analogy between the propagation of light in an optically inhomogeneous medium and the minimization of the integral functional.

Let we are given a metric space X, points a and b, and $f(t,x,y)$ be a piecewise continuous function, which shows the instantaneous speed of movement. There are also some moving obstacles, whose boundaries are specified by equations $H_k(t,x,y)=0$, $k=1,...,n$.

The minimum moving time between two points $a,b \in X$ is determined as follows:

$$\rho(a,b)=\min_{\Gamma\in G(a,b)}\int_{\Gamma}\frac{d\Gamma}{f(t,x,y)},\ \Gamma^{*}=\operatorname*{argmin}_{\Gamma\in G(a,b)}\int_{\Gamma}\frac{d\Gamma}{f(t,x,y)},$$

where $G(a,b)$ is all continuous curves, which belong to $X\setminus\bigcup$ and connect the points a and b, Γ^{*} is the fastest path found.

We propose a numerical algorithm that allows us constructing the fastest paths for one or several UAVs in the presence of both permanent and moving obstacles. Besides, we implement the curve-shortening flow method [1] and compare the results.

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KNOWLEDGE MAPS AS A COMPONENT OF THE KNOWLEDGE ECOSYSTEM

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There is a common misconception in most organizations that knowledge management is simply adding information to a repository. In fact, the main function of knowledge management is to store and manage all available information in such a way that employees can easily find and use it, and team members have the opportunity to add information to the knowledge base themselves. In addition to knowledge database management and storage, it is necessary to improve cooperation between departments and encourage employees to share their knowledge with each other, to form a culture of knowledge sharing [1].

The main indicators that the knowledge management system requires improvements when employees [2]:

- do not have free time to share new knowledge or skills;
- they cannot correctly provide information orally or in writing.;
- I have no experience in structuring my skills;
- shy to ask questions;
- I do not have access to knowledge sharing software.

Various knowledge management methods and tools are used to improve the above indicators.

In this paper, the methods of knowledge mapping are considered. The specifics of the development of the knowledge map considered in this paper are a combination of business approaches and ontological engineering. The competencies of employees (knowledge, skills, experience), as well as articles and documents in which they participated, will be used as assets for mapping. It is the use of the possibilities of operating with employee competencies in the form of digital data that is one of the important and key parts of the organization's knowledge management. Such a concept will make it easier and faster to realize the potential of the organization [3].

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KNOWLEDGE ECOSYSTEM AS A NEW APPROACH TO KNOWLEDGE MANAGEMENT

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Based on the analysis of foreign sources [1], the idea of a knowledge ecosystem as a new approach to knowledge management is considered and its definition is introduced: knowledge ecosystems are “organizations consisting of various actors united by a joint search for valuable knowledge, and at the same time having independent activities for outside the knowledge ecosystem."

The differences between a knowledge ecosystem and the original concept of a business ecosystem are identified: 1) knowledge ecosystems are geographically grouped around a key actor; 2) the key actor is often a university or research organization; 3) when developing and creating a common knowledge base, the focus is on collaborative research rather than knowledge use; 4) the knowledge ecosystem consists of hierarchically independent but interdependent heterogeneous participants who promote the transformation of research knowledge.

Four ecosystem factors have been identified, which relate to: ecosystem subjects; to the nature of their activities; to organizational coherence of participants and activities in the knowledge ecosystem; to ecosystem-level outcomes or artifacts.

Artifacts in an ecosystem context refer to the products and services, inputs and outputs (including tangible and intangible resources) that are jointly created by all participants as outputs at the ecosystem level. Knowledge ecosystems differ from other types of ecosystems in the sense that their artifacts or ecosystem-level outputs are typically research-based knowledge and associated applications.

The entities that span the structure of the knowledge ecosystem and the underlying organization can be divided into two categories: 1) participants (developers); 2) beneficiaries (users). Members can become beneficiary and vice versa. The competitive advantages provided by the development and use of knowledge ecosystems are also considered.

An analysis of Russian literary sources showed that the direction of the “knowledge ecosystem” in our country is poorly developed, which is confirmed even by differences in terminology: for example, the term “knowledge management ecosystems” is used, references in publications are only to Russian-language sources; at the same time, problems in the development of such ecosystems in Russia are noted.

In our case, it is proposed to use as a scientific prototype of an ecosystem of knowledge in the energy sector the IT infrastructure of systemic research in the energy sector developed under the leadership of the author (Fig. 1), which includes Databases and Knowledge Bases and Tools (Services) for working with them [2].

The levels of Models, Instrumental IT - environments, levels of IT - infrastructure and Management levels are distinguished. At the Model level, Semantic models, Mathematical (including Simulation) and Information models (Data models) are distinguished. To interact with them, a Knowledge Management Language is proposed. The level of Instrumental environments includes: 1) the Intelligent IT-environment to support semantic modeling (including Expert Systems); 2) Ontological Knowledge Portal; 3) a Data and Knowledge Storage that integrates Knowledge Bases, an Operational Database and an Aggregated Database; 4) a Tool Environment for building Digital Twins, integrating the five basic components of creating a Digital Twins and precedents for the Digital Twins.

The levels of IT - infrastructure include the levels of Digital Twins of units, objects and Energy Systems, as well as Smart Digital Twins and the Fuel and Energy Complex as a whole. To integrate them, it is planned to develop a special Software Platform.

Meta descriptions about the composition of levels is stored in the Repository.

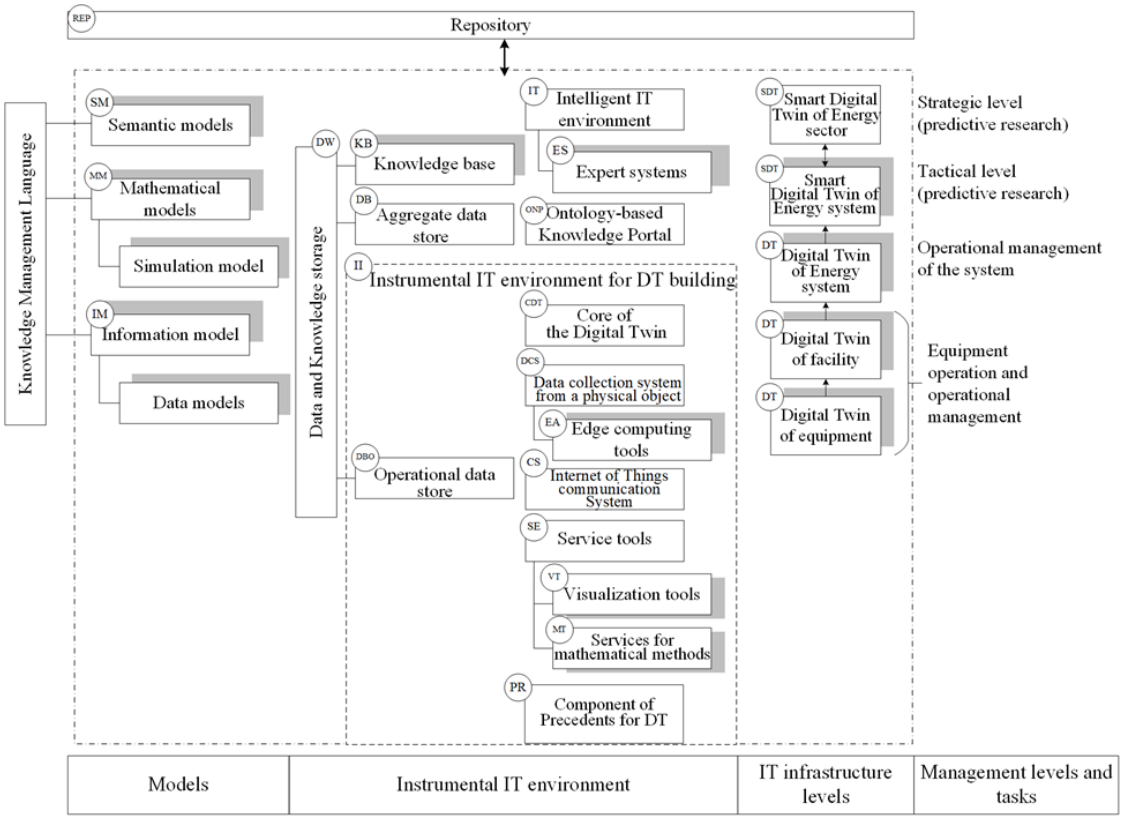

Fig. 1. Architecture of IT infrastructure for system research in the energy sector

In conclusion, the difference between knowledge ecosystems in business and science is considered [3]: in business, the main thing for knowledge ecosystems is the accumulation of knowledge as a strategic resource and its processing to ensure a competitive advantage; for knowledge ecosystems in science - the accumulation and processing of knowledge to obtain new knowledge, in the future - the application of accumulated knowledge for practical purposes and obtaining competitive advantages both for scientific organizations and, for example, as in our case, for energy organizations.

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AN APPLICATIONS OF ARTIFICIAL INTELLIGENCE TECHNIQUES IN ENERGY: SCIENTOMETRIC REVIEW

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Artificial intelligence (AI) techniques have become highly popular in recent years and are being actively utilized for a wide range of research and development, including many applications related to the energy sector. The main advantage of the approaches based on AI is their ability to obtain stable solutions to nonlinear and weakly formalizable problems. The report provides a comprehensive bibliometric analysis to better understand the evolution of artificial intelligence in the energy field. This study is based on a data from the international database Scopus, and a dataset was obtained from publications from 2000 to present. We use the bibliometric tools VOS viewer, CiteSpace to build knowledge maps. The study shows that technologies based on artificial intelligence are actively used by researchers around the world to solve a wide range of problems, for example, in the electric power industry, such as the construction of intelligent control systems; safety control, risk assessment in the energy system; stability control and prediction of (un)stable modes; ensuring transient stability, forecasting workload during short-term planning of operating modes, short- and long-term forecasting and generation control for renewable energy sources. The evolution and trends of research on AI topics in energy sector are discussed.

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OPTIMISING ENERGY CONSUMPTION IN INDUSTRY: A REVIEW OF METHODS FOR FORECASTING ELECTRICITY CONSUMPTION IN INDUSTRIAL ENTERPRISES

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In the conditions of modern industry, effective management of energy consumption is a key factor for increasing the competitiveness of enterprises and reducing the negative impact on the environment. In this context, the analysis of power consumption forecasting methods becomes an integral part of the strategy for managing energy resources of industrial enterprises.

The relevance of the topic of electricity consumption forecasting for industrial enterprises is due to the need to optimise energy consumption, reduce energy costs, and reduce the load on the energy infrastructure. Effective forecasting of electricity consumption allows enterprises to plan their activities more accurately, optimise production processes and improve overall energy efficiency.

The purpose of this literature review is to systematise and analyse existing methods of electricity consumption forecasting at industrial enterprises in order to identify the most effective and promising approaches.

In order to achieve the set goal, the following tasks are set before the study:

1. Studying the main methods of electricity consumption forecasting used at industrial enterprises.
2. Analysing the advantages and disadvantages of different approaches to electricity consumption forecasting.
3. Identification of key factors affecting the accuracy of electricity consumption forecasting at industrial enterprises.
4. Formulation of recommendations to improve the process of electricity consumption forecasting in order to optimise energy consumption at industrial enterprises.

There are several basic methods and approaches to forecasting electricity consumption that are widely used in industry. Some of them include:

1. Statistical methods: This approach is based on analysing historical electricity consumption data. Statistical methods may include time series methods, regression analysis, moving average methods and others.
2. Machine learning methods: Machine learning is becoming increasingly popular in the field of electricity consumption forecasting. Machine learning algorithms such as neural networks, support vector method, random forests and others can be used to predict electricity consumption based on historical data and other input parameters.
3. Physical models: This approach is based on physical principles and modelling of processes that affect electricity consumption. Physical models can take into account factors such as weather conditions, type of equipment, production processes and others.
4. intelligent energy management systems: These systems use a combination of prediction, optimisation and control algorithms to effectively manage energy consumption in industrial plants.
5. Integrated Energy Management Systems: These systems combine various energy management techniques and approaches, including forecasting, monitoring, load management and other functions to optimise energy consumption.

Each of these methods has its advantages and limitations, and the choice of a particular approach depends on the specifics of the industrial plant, available data, and the goals of power

consumption forecasting. A combination of different methods and approaches often provides more accurate and reliable power consumption forecasts.

One such method is the Principal Component Analysis (PCA), which is a statistical technique used to reduce the dimensionality of data by transforming multivariate data into a new set of variables called principal components [1]. PCA allows us to highlight the most important aspects of the data and reduce the dimensionality of the data while retaining as much information as possible.

The application of principal component method in forecasting electricity consumption of industrial plants with continuous nature of production can be useful due to the reduced dimensionality of the data. PCA reduces the dimensionality of the data by identifying the most important variables that explain most of the variation in the data. This can be useful when analysing large amounts of electricity consumption data in an industrial plant. PCA also helps to highlight major patterns or regularities in the data, which can be useful for predicting future electricity consumption based on previous data. Relationship identification PCA can help in identifying the relationships between different electricity consumption variables in a plant, which is useful in understanding the factors affecting electricity consumption. By reducing the dimensionality of the data and highlighting the most important variables, PCA can help to improve the performance of electricity consumption forecasting models in industrial enterprises.

However, when using PCA for electricity consumption forecasting, it is important to consider the characteristics of the data, handle outliers correctly, and consider possible limitations of the method. It is also important to further analyse and compare with other forecasting methods to confirm the effectiveness of PCA in the specific context of an industrial plant with continuous production.

Electricity consumption forecasting using Long Short-Term Memory (LSTM) neural networks is a popular approach in the field of time series forecasting [2]. LSTM is a special type of recurrent neural network that can efficiently process and remember long-term dependencies in data.

This technique is characterised by the model's ability to handle long-term dependencies: LSTM networks have the ability to efficiently capture and exploit long-term dependencies in data, which can be important for accurate forecasting of electricity consumption subject to seasonal and other long-term influences. Since electricity consumption is usually time dependent, LSTM neural networks can adapt to consistent data and account for changes in consumption over time. LSTM networks can be configured to account for various factors affecting electricity consumption such as weather, day of the week, holidays and other variables. To predict electricity consumption, LSTM neural networks are trained on historical data, which allows the model to learn patterns and trends in consumption to more accurately predict future values. For successful application of LSTM neural networks, it is necessary to have sufficient and good quality historical data on electricity consumption.

Using LSTM neural networks to predict electricity consumption can be an effective tool to improve the accuracy of forecasts and optimise electricity management in industrial plants and other areas where predicting future energy consumption is important.

Short-term forecasting of natural gas consumption parameters at industrial enterprises appears to be the most important link in energy cost management, which is the basis of a modern energy efficiency strategy [3]. This process has the potential to enable enterprises not only to plan their gas costs, but also to optimise production processes and to manage energy consumption with the highest degree of efficiency. Cost optimisation is made possible by anticipating natural gas consumption in the short term, enabling companies to allocate their energy resources more accurately, reducing costs and improving efficiency.

Production management is designed to adapt production processes to anticipated changes in energy consumption, helping to optimise production operations and create a more flexible and efficient production system. Price-dependent cost management is made possible by taking into account fluctuations in natural gas prices. Short-term forecasting of consumption allows enterprises to respond adequately to price changes and make balanced decisions on gas purchases and utilisation, taking into account the current market situation. Energy efficiency improvement is made possible by analysing short-term gas consumption forecasts. This allows identifying opportunities to optimise energy consumption and improve the overall energy efficiency of the enterprise. The use of modern forecasting methods, including statistical models, machine learning and physical models, opens new horizons for accurate forecasting of natural gas consumption parameters.

Overall, short-term forecasting of natural gas consumption parameters is becoming an indispensable tool for efficient energy cost management in industrial enterprises, contributing to production optimisation and improving the competitiveness of the enterprise in modern industry.

The rest of the literature review as well as the results and conclusions will be later in the full version of the paper after the thesis is approved.

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METHODS OF BUILDING DIGITAL TWINS OF RENEWABLE ENERGY SOURCES BASED ON ONTOLOGY ENGINEERING

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One main problem arises in the development of renewable energy sources (RES) facilities - their behavior, especially wind farms, is highly dependent on external factors, primarily weather conditions. Accordingly, for effective use of RES it is necessary to develop not only control systems, but also systems for predicting the behavior of these objects in changing conditions. In this regard, the work on digitalization of the energy sector is currently underway, which is directly stated in the Energy Strategy of the Russian Federation for the period up to 2035 [1]. One of the modern trends in digitalization is the technology of digital twins (DT).

At present, the construction of a digital twin is a non-trivial task due, on the one hand, to the lack of modern domestic IT solutions in the transition to digital and smart renewable energy, and, on the other hand, to the low demand for or difficulty in applying the results of fundamental scientific research in this area. As a rule, the digital twin includes mathematical and information models. At the same time, there are no methodologies for their integration and joint use as part of the DT. Obviously, it is necessary to develop a methodological approach to the construction of a DT, including the methods of construction of DTs, their architectures and the main integrable models.

The paper proposes, as the basis of such a methodological approach, an ontological approach to the construction of DT, which is based on ontological engineering of the subject area, and mathematical and information models are built using the developed ontologies.

Computing technology of the present time provides wide opportunities for realization of convenient graphical interfaces for interaction with mathematical, ontological, informational and other models to the end user. Graphical representation of inputs, outputs and internal state of models allows to increase practicality and productivity of work due to the fact that the user can change parameters of models of separate objects of the modeled system by simple selection of a graphical primitive (representing a certain object of a wind power plant, for example, a wind generator) represented on the scene or due to the fact that the result of modeling will be presented graphically, not in the form of tables or numbers, which will improve the interpretability of modeling results

The paper proposes an approach to the construction of such systems based on the use of ontology engineering as a design basis.

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DEVELOPMENT OF KNOWLEDGE FILTERING TECHNOLOGIES AND TOOLS FOR PROCESSING KNOWLEDGE AND META-KNOWLEDGE

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The paper analyzes knowledge filtering technologies based on the function they perform in the process of processing knowledge and metaknowledge.

The purpose of the work is to explore ways to identify the basic stages for filtering knowledge and meta-knowledge. Knowledge in large amounts of information contains many errors, distortions and requires time to correct them. Alternative versions of different people in understanding the essence of the concepts used and the continuous competitive struggle of opinions practically blocks the evolutionary development of various directions at the level of knowledge.

The main purpose of working with knowledge in the filtering process is to identify and preserve true knowledge, separating it from false ones. Meta–knowledge is strictly ordered structural information obtained in various ways, formalized in various ways, which forms certain structural properties of existing reality in consciousness. The concept of meta-knowledge includes rules, methods of planning, modeling, learning, and conceptualization tools that modify knowledge about the subject area. Meta-knowledge, being more formalized and compact forms with a higher information density of their structures, provides advantages in all processes of collecting, processing and transmitting both data and information.

In the process of extracting, forming, and working with knowledge, there are processes of knowledge autoformalization (the process of formalizing professional knowledge performed by the bearer of this knowledge), knowledge filtering in the process of semantic identification of analyzed concepts. When working with meta-knowledge, it is proposed to use meta-formalization and meta-filtration of meta-knowledge, respectively.

The following formal representation of the extended system of meta-knowledge with the allocation of layers is proposed: G={S,D,I,K,M}, where

S – signals (nature signals, civilization signals, brain signals);

D – data (nature data, civilization data, brain data);

I – information (information of nature, information of civilization, information of the brain);

K – knowledge (foreknowledge, basic knowledge, post-knowledge);

M – meta-knowledge (subject knowledge, basic meta-knowledge, post-knowledge).

When describing signals, data and information, it is proposed to consider the layers of nature, civilization and the brain. When working with knowledge and meta–knowledge, layers of prior knowledge and meta-knowledge are considered - foreknowledge and subject knowledge, basic knowledge and basic meta-knowledge, as well as predicted post-knowledge and post-knowledge.

Methods of meta-analysis, metasynthesis, meta-analogies and meta-communication are used in the tasks of developing methods of processing meta-knowledge.

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HYBRID ALGORITHMS FOR NONLOCAL OPTIMIZATION BASED ON HARMONY SEARCH, FIREFLY SWARM, FLOWER POLLINATION AND L-BFGS METHODS

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The problem of finding the global optimum of a multi-extremal target function remains one of the most complex and relevant in the theory and applications of mathematical programming and optimization of dynamic systems. Typically, robust nonlocal optimization procedures rely on a balance between global scanning of the search space ("exploration") and local improvement of the obtained solutions ("exploitation"). Accordingly, the iteration of the absolute extremum search algorithm should include two stages: a global search in the feasible set and local refinement using gradient methods in areas where the presence of a global optimum is likely.

The paper proposes an approach that takes advantage of bioinspired algorithms for exploring the admissible set and gradient methods for local optimization, which makes it possible to construct computational schemes that underlie effective methods for solving nonlocal search problems. The indicated approach to the numerical study of problems of searching for the global extremum of multimodal target functions is based on the use of harmony search, firefly swarm, flower pollination [1,2] and limited-memory Broyden-Fletcher-Goldfarb-Shanno (L-BFGS) [3] algorithms. Two-method computational schemes for solving multi-extremal optimization problems in the C language using uniform software standards are proposed and implemented.

The developed algorithms were investigated on a collection of non-convex test problems characterized by different levels of complexity. The results of numerical experiments obtained using the proposed algorithms and modifications of the genetic search, differential evolution and biogeography methods [1,2] were compared. All optimization algorithms based on hybridization with the L-BFGS local search method showed significant improvements over the original bioinspired algorithms. The results of computational experiments confirming the performance of the developed algorithms are presented.

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APPLYING AN AGENT-SERVICE APPROACH IN THE DEVELOPMENT OF A DIGITAL TWIN

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In the task of designing a digital twin of renewable energy sources, it is required to develop a software architecture. As a method of development, it is proposed to use an agent-server approach to the development of the architecture of software components of the digital twin.

An agent is a completely autonomous process capable of reacting to the execution environment and causing changes to it, possibly in cooperation with users or other agents. Often agents are understood as computational units that support local states and parallel computation, and are able to reach the states of other agents in communication processes and automatically perform actions under some environmental conditions [1]. In the system, an agent acts as a service that provides services to other agents or external users. Agents can perform work in parallel, cooperatively and interacting with each other. Such systems containing agents interacting with each other are called multi-agent systems.

There are three groups of agents-services: Server, Client, Hardware. The Client group contains the Coordinator and Predictor agents. «Server» contains agents of mathematical models (solvers) and databases. Agents of data collection and control agents realize the «Hardware» group. Data collection and agent management agents implement the «Equipment» group. Each agent in the group can be decomposed into simpler components. Adequate operation requires the development of agent scripts for their interaction and their description. The use of agent-service method gives modularity to the architecture, which facilitates the integration of other agents.

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ABOUT OBJECT RECOGNITION ALGORITHMS IN SOLVING SOME PROBLEMS IN ANIMAL HUSBANDRY

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In livestock farming, there are problems that have either complex and costly solutions, or they cannot be solved without the use of digital technologies. This paper considers two problems. The first of them is the monitoring of farm animals (cattle, sheep, horses) on pastures. The second task is related to monitoring the development of animals: the size of the herd, assessment of the individual characteristics of each animal during the fattening season: body length, height at the withers, weight, growth rate, feed consumption and other morphometric and productive characteristics, including the identification of sick animals. Computer vision methods can be used to solve these problems.

Computer vision methods are divided into three groups: classical methods, machine learning and artificial neural networks, deep learning. The table shows a comparison of these methods.

Table 1. Comparison of computer vision methods

Computer vision methods	+	-
Classic computer vision	Does not require training data Not demanding on hardware	Long-term identification of patterns in data Less accuracy compared to MO
Artificial neural networks (perceptron)	Accurate enough Resistant to overfitting Capable of detecting complex dependencies	Requires a large amount of training data
Deep learning	Superior to previous short circuit methods	Requires a huge amount of training data and computing power

Now there are no systems that allow monitoring of different species of animals in pastures, where extensive technologies for the maintenance and cultivation of agricultural animals are used (for example, Russia, Mongolia). To solve this problem, you can use unmanned vehicles that will record videos in a certain territory. After that, you can apply recognition methods based on a trained neural network. With a high -quality odometry of drones, it is possible not only to count animals of different species in the territory under consideration, but to determine their exact location at the time of shooting.

For various options for the second problem, the existing solution using neural networks is a contactless weighing of pigs, a system for monitoring the behavior of cows, a system to determine the parameters of wild animals. The following methods can be improved these systems: Improving the quality of work due to the evidence of data for teaching classic images processing algorithms, expanding the viewing base, combining algorithms of various systems to create a more multifunctional system.

As a result, we can conclude that for detecting and recognizing objects, you can use algorithms similar to existing solutions. But their refinement is possible to increase accuracy and performance. For detecting and recognizing the species, you can apply Yolo V8. Analysis of features is carried out using the Densenet architecture more flexible for learning. To improve the quality of its characteristics, data evidence is performed. It is also necessary to collect your own dataset for training. After that, it should be marking and augmentation using the Roboflow service.

CONTENT

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