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IDEA MONITORINGU SYSTEMÓW Z ZASTOSOWANIEM INTELIGENTNEGO MULTI-AGENTA

Streszczenie: W pracy zaproponowano nową ideę budowy inteligentnych systemów monitoringu z zastosowaniem agentów. Badane są działania agentów przetwarzających informację (agentów-konwerterów). Postawiono i analizowano hipotezę o przydatności tychże agentów. Ich użyteczność potwierdzono eksperymentalnie dla własnej aplikacji. Efektywność ma związek ze wzrostem różnorodności modeli syntezy poprzez kombinację rezultatów interakcji autonomicznych inteligentnych agentów. Prowadzi do wzrostu adekwatności globalnej funkcjonalności inteligentnych systemów monitorowania.

Słowa kluczowe: nowy pomysł, monitoring, inteligentny agent, synteza modeli, GMDH

THE CONCEPT OF MULTI-AGENT INTELLECTUAL MONITORING SYSTEMS

Summary: A new concept of building an intelligent monitoring system based on an agent approach is presented. The work of agents-converters of information is investigated. The hypothesis that increasing the diversity of model synthesis by combining the results of the interaction of autonomous intellectual agents leads to an increase in the adequacy of the global functional dependence of the intellectual monitoring system is experimentally proved.

Keywords: The concept, monitoring, intelligent agent, synthesis of models, GMDH

1. Setting the problem

It is known [1] that Intelligent Monitoring Information Technology (ITIT) is intended to provide knowledge of decision-making processes by organizing continuous observations and processing their results. It is implemented in the form of Intelligent Monitoring System (IIS) [2] in accordance with the external order of the decision maker (ODM). Intellectual monitoring information technologies are individual and are not interchangeable.

Usually, [3] ODM requires information about the properties of objects reaction of which is significant. This information is contained in the MIT Knowledge Base. They

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are obtained during the monitoring of the objects and the processing and transformation of their results.
An agentic approach to building information technology (IT) involves the implementation of the stages of IT by organizing the interaction of autonomous software objects [4]. Many of the tasks performed in the implementation of the ITIT stages require the use of intelligent agents. Software agents become intellectual when they use knowledge bases in one form or another [5]. Intellectual agents are used in ITIT that use a specific form of knowledge base - the model knowledge base [6], which is built by hierarchically combining models that describe the properties of a monitored object..

2. Analysis of recent research and publications

The main processes that implement the technology of multilevel socio ecological monitoring are the formation of an array of observations and their transformation into a form that is convenient for later use [7]. Survey results are presented in the form of a two-dimensional data set called the original description. According to the results of the analysis of the informative features of the original description, an array of input data is built and fed to the input of the model synthesizer.
The process of using multiple intelligent systems to increase the power of multilevel monitoring technology is appropriate to build on the achievements of existing multi-agent technologies [8]. Several structures of intellectual agents have been described, which are suggested to be typical [9]. But the process of developing intelligent agents' behaviors research requires additional research which should provide them with sufficient diversity to adapt to environmental changes.

3. Pointing out the unsolved aspects of the problem

Today there are results of studies of the processes of application of the intellectual monitoring technology in cases where it is possible to obtain an array of numerical characteristics of the objects of monitoring sufficient informativeness [10]. The focus of this work is on cases where the informative nature of the results of observations of the monitoring facilities is insufficient to construct utility models.
The task is to create technology for the construction of utility models in the conditions of insufficient information of the results of observations.
To accomplish this task, new principles of ITIT construction and their implementation in the form of IIA are being developed. One such principle is the use of agent-based approaches in solving monitoring tasks and building an MIS knowledge base [2].

4. The aim of the article

The aim of the article is to investigate the process of model formation in a multiagent intelligent monitoring system and compare the characteristics of simulation results with those obtained in the traditional way.

5. Results

Applying an agent approach for building information technology for intelligent monitoring requires the formation of new monitoring principles, and combining them into a separate concept. The concept contains the following principles:

- intelligent monitoring information technology is designed to provide information to decision-making processes to reduce uncertainty in the choice of strategies;
- information about the properties of the monitoring objects is obtained by organizing continuous observations, processing and converting their results;
- intelligent monitoring technology is built individually for each decision-making process;
- the content of the monitoring results is determined in accordance with the purpose of the decision maker;
- use of a model knowledge base;
- use of an agent approach for the formation of structures of monitoring intellectual systems;
- use as algorithms to convert information of models of monitoring objects and their hierarchical combinations;
- formation of a list of informative features based on the results of modeling;
- use of upstream element synthesis method to coordinate interactions of intellectual agents;
- the principle of maximum diversity of databases of model knowledge of agents-converters of information;
- aggregation of agents of the monitoring intellectual system.

A multi-agent approach in MIS is the interaction of autonomous agents who synthesize models with their own approaches that share a common goal. Agents are built on different types of models synthesized by genetic algorithms, MSA [12], on neural networks of different topologies, based on hybrid methods.

It was hypothesized that increasing the diversity of model synthesis by combining the results of the interaction of autonomous intellectual agents leads to an increase in the adequacy of global functional dependency. Each agent builds its own model knowledge base according to its purpose. Modeling knowledge base is used by agents to convert monitoring results $X = \{x_1, x_2, \ldots, x_n\}$ to the form of monitoring object status indicators $Y = \{y_1, y_2, \ldots, y_m\}$:

$$Y = f(X) . \tag{1}$$

The structure of the model knowledge base involves the use of multiple converters agents that synthesize models by different methods. The data converted results of each agent are evaluated for their ability to provide adequacy or accuracy at least well. After verification, the outputs of the agent whose models are best are used. Where the characteristics of the output signals do not meet the advanced quality criteria, multi-layer modeling technology, predictor combination or similar technology will be used to increase the diversity of multi-agent synthesis of multi-layer model of monitoring objects.

To test the formulated hypothesis, an experiment was conducted. Dependences of Cherkasy region population morbidity on environmental indicators were modeled. Characteristics of the concentration of harmful substances in the air of the living area and indicators of the level of radiation in food were used as indicators of the state of the environment . Table 1 presents the characteristics that were used as the variables of the set X and the model indices belonging to the set Y of the expression (1).

Table 1. List of features

No	Index	Variable
1	Place code	x_1
2	Time, year	x_2
3	Nitrogen oxides (NO), mg/dm^3	x_3
4	Sulfuric anhydride (SO_2), mg/dm^3	x_4
5	Carbon monoxide (CO), mg/dm^3	x_5
6	Hydrocarbons [$Cn(H_2O)n$], mg/dm^3	x_6
7	Manganese dioxide (MnO2), mg/dm^3	x_7
8	Ammonia (NH3), mg/dm^3	x_8
9	Soot (SiO_2), mg/dm^3	x_9
10	Toluene ($C_6H_5CH_3$), mg/dm^3	x_{10}
11	Butyl acetate [$CH_3(CH_2)_3)OOCH$], mg/dm^3	x_{11}
12	Acetone (CH_3COCH_3), mg/dm^3	x_{12}
13	Light organic compounds (ЛОС), mg/dm^3	x_{13}
14	Calcium oxide (CaO), mg/dm^3	x_{14}
15	Xylene (C_8H_{10}), mg/dm^3	x_{15}
16	Ethyl acetate ($CH_3COOC_2H_5$), mg/dm^3	x_{16}
17	Tetraethyl lead ($(C_2H_5)_4Pb$), mg/dm^3	x_{17}
18	Gasoline (C_5H_{12}), mg/dm^3	x_{18}
19	Phenol (C_6H_5OH), mg/dm^3	x_{19}
20	Strontium-90 A. Milk and dairy products, Bq/kg	x_{20}
21	Strontium-90 A. Meat and meat products, Bq/kg	x_{21}
22	Strontium-90 A. Fresh fish, Bq/kg	x_{22}
23	Cesium-137 A. Milk and dairy products, Bq/kg	x_{23}
24	Cesium-137 A Meat and meat products, Bq/kg	x_{24}
25	Cesium-137 A. Fresh fish, Bq/kg	x_{25}
26	Strontium-90 A. Vegetables, Bq/kg	x_{26}
27	Strontium-90 A. Bread, Bq/kg	x_{27}
28	Strontium-90 A. Groats, Bq/kg	x_{28}
29	Cesium-137 A. Vegetables, Bq/kg	x_{29}
30	Cesium-137 A. Bread, Bq/kg	x_{30}
31	Cesium-137 A. Groats, Bq/kg	x_{31}

To investigate the array of input data, 9 data converter agents were used, the algorithms for model synthesis were not repeated.

Respiratory morbidity of the population of Cherkasy region (Ukraine) during 2015-2016 was used as the simulated status indicator. The agent outputs are the results of simulation of observation points, which were not used in model training. The results of the multi-agent structure of the monitoring intelligent system were compared with the output signals of the model built by a synthesizer with the traditional structure. As an indicator of the quality of the models, the average error in modeling the observation points of the examination sequence, which were not used in the model training, was used. Table 2 presents the results of the studies

Table 2. Modeling results

Models	Traditional Model	Agent 1	Agent 2	Agent 3	Agent 4	Agent 5	Agent 6	Agent 7	Agent 8	Agent 9
Mistake, %	11,18	9,71	5,71	13,54	32,66	1,26E+17	16,08	10,88	11,79	10,33

According to the results presented in Table 2, Agent 2 received the highest quality model the oversight of which in the modeling results is more than half the results of the model built by a traditional synthesizer. The data conversion results of this agent will be used as output signals of the global functional dependency of the multiagent monitoring intelligent system. The hypothesis thus formulated has received experimental confirmation.

6. Conclusions and suggestions

In order to empower abilities of intellectual monitoring information technologies, it is proposed to use an agent-based approach to building monitoring intelligent systems. A new concept of intelligent monitoring based on a multi-agent approach is presented. Implementing the principle of agent aggregation, a study of the functioning of agents of information converters was carried out. The hypothesis that increasing the diversity of model synthesis by combining the results of the interaction of autonomous intellectual agents leads to an increase in the adequacy of global functional dependence is experimentally proved. The global functional dependence obtained from the multi-agent model test results in modeling results enables to gain modeling results characteristics of which are more than twice the characteristics of the model obtained by a traditional synthesizer.

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