Formation of intelligent agents of the information and analytical system of enterprise safety management

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Abstract

Introduction. Research has been conducted to form a conceptual model of the intellectual information and analytical labor protection management system of food industry enterprise.

Materials and methods. For solving the tasks, methods of system analysis, basic classes of architecture of agent systems, mathematical logic, the theory of formal systems and calculations characteristic of traumatic processes at industry enterprises have been used.

Results and discussion. It is determined that the proposed complex automation system of labor protection management for companies in food industry, can be used to improve project management decisions on operational analysis of working conditions in the enterprise, definition of areas to prevent occupational injuries and organizational measures for the protection of labor basis. The paper proposes an intelligent agent model in the structure of an information-analytical management system of industry enterprises, which is different due to the way the information space of intelligent agents is formed, the availability of a model for behavior selection mechanism and the contents of intelligent agent's goal definition model, which allows to determine the dynamics of development of multi-agent environment, complicated hierarchy of goals in the information and analytical labor protection management system at enterprises and form various operation strategies for intelligent agents. The results of work contribute to the principle application development of occupational safety as far as the diagnosis and modeling of extreme situations and evaluate their consequences.

Conclusions. The most rational solution is to improve the safety of work of the enterprise by introducing elements such as data elements and intelligent agents into the information and analytical labor protection management system.

Introduction

Based on the analysis of information and analytical systems used in the labor safety field, depending on the purpose of their functioning, the tasks to be solved, and the specifics of data collection and processing, it is possible to single out information-reference, information-calculation, information-control and intelligent analytics platform [1, 2, 3].

The task of increasing the safety of labor in food industry enterprises is most rationally solved by introducing such components as data elements and intelligent agents into the information management system.

The paper proposes an intelligent agent model in the structure of an information management system in food industry enterprises, which is different due to the way the information space of intelligent agents is formed, the availability of a model for behavior selection mechanism and the contents of intelligent agent's goal definition model, which allows to determine the dynamics of development of multi-agent environment, complicated hierarchy of goals in the information management system at enterprises and form various operation strategies for intelligent agents.

The legislation of Ukraine on labor safety management provides for the following division of responsibilities for the labor safety management at any enterprise: in general, director (employer) and his/her deputies carry out the labor safety management at the production facility; in the divisions – their heads; organizational and methodological and supervisory activities in the field of labor protection, management decisions preparation and control over their implementation is carried out by the work safety service, which is directly responsible to the director.

During day-to-day operations, specialist services (divisions) of the food production facility are processed, systematized, stored large information volumes. Unfortunately, as practice shows, due consideration is not given to the use of accumulated data for decision analysis and operational management. Remain unresolved issues of structuring data, categorized (production factors and working conditions, instructions, regulations, etc.) and the choice of valuable information.

First, the issue is that we have to analyze and predict the manufacturing situations of labor safety, and this is a significant amount of information that cannot be analyzed in a timely manner without modern information technology (IT). Information technology is an integral part of our modernity, in particular its main component with a high level of development of introducing a new management style into our lives. The information distribution of and information support construction for labor safety in most ways characterizes the art of management. The introduction of new models and principles in the information provision of labor safety in a food production facility with the use of modern information technologies, plays a decisive role in the validity and timeliness of management decisions taken on the basis of monitoring labor conditions, occupational disease and injury statistics, the production risks analysis and the effectiveness of measures to limit and reduce them [4].

Therefore, a modern information and analytical system for health and safety management at a food production facility should be organized taking into account the clear interaction of the head of the health and safety department with the heads of all structural subdivisions of the food production facility for adequate and constant management, taking into account all factors affecting the health and safety management state, and provide heads of structural units with an optimal measures set to ensure labor safety.

The problems of ensuring the stability of operation of difficult intelligent information and control systems, which include of the industry enterprises, was first staged in the works of national scientists.

Key stages of stability theory lately was developed in the work of O.V. Barabash [5] and others. The overview of the issue of verification items base knowledge of management information systems was in the next works [6, 7].

The analytics platforms evaluation existing in the labor safety field shows that there is a positive experience of their use for solving problems of injury rates administrative monitoring and so on. Despite the considerable advantages that the use of information analysis systems provides, it should be noted that they are limited. Traditionally, there are no functions for developing managerial decisions in information analysis systems, this leads to irrational use of available data, and in some cases – to the insufficiently substantiated managerial decisions adoption. [14, 15, 16, 17].

Materials and methods

A research object is to ensure safety labour at the food industry enterprise.

The subject of the research is an increase safety of labour of food industry enterprise on the basis of the worked out conceptual model of intellectual agent in the structure of information-analytical system of labor protection management at the enterprise, institution, organization.

For the construction of information-analytical system control system by labor protection at the of the food industry enterprise is chosen the object-oriented programming [21, 22], methods of system analysis [30, 31, 32], mathematical logic and the theory of formal systems and numerals [33] for reducing an occupational injuries [3, 18, 19, 20].

Results and discussion

Modern analytical platforms [22, 23, 24] should be focused on supporting management activities [25, 26]. The creation of such systems involves the application of decision-making theory methods [27], mathematical modeling and forecasting methods, decision-making theory and expert judgment [28]. The main task to be solved by modern IIS is to transform the accumulated data on the status of the object of management of labor safety (the activities of functional services and structural units to ensure safe and healthy working conditions at workplaces, production sites, workshops and industry enterprises in general) in a form that allows the head (the labor safety department head) to adequately assess the labor safety object state, assess the situation development and make a sound management decision [29]. That is, the well-known state of the management object of labor safety should be aligned with such a management strategy, which is the physical implementation of management decisions, from the admissible set. In this case, the chosen solution is optimal based on a definite list of criteria for decision-making and restrictions.

A combined model of an intelligent agent information management system. Based on the analysis of the characteristics and shortcomings of known models of IA, it is proposed to define IA as the structure of the form

$$IA = <NIA, SA, VIA, MVB, VO>,$$

where NIA – intelligent agent's name; SA – structure of attribute, which is defined similarly to the structure of attributes of information objects (IO); VIA = {IA} –plenty of attachments

IA; MVB – the mechanism of the model of functioning selection, VO = {O} –plenty of information objects, that implement the scenarios of IA work.

Intelligent agent based on the criteria select the model of functioning inherent in the MVB, makes a decision about implementation in a given time a certain scenario and the corresponding appropriative IO.

Intelligent agents, which have only the name (IA = <NIA,∅ , ∅ , ∅ , ∅ >), can be called nominal, similarly to nominal IO. By the content nominal IA are not differ to nominal IO. Similar situation is also with the parametric IA rank (IA =<NIA, SA, ∅ , ∅ , ∅ >). By the feature of presence of mechanism behavior of IA is possible to allot them in 2 classes: active (MVB ≠∅ & VO≠∅) and passive (MVB = ∅ & VO = ∅). The passive IA class have subclass of passive agents – cover, which are used for connecting the objects inside the (IA = <NIA, ∅ , VIA, ∅ , ∅ >). Passive IA (IA = <NIA, SA, VIA, ∅ , ∅ >) have attribute, which can be constant and it allows them to create an intermediate level of the hierarchy. The active IA class has a subclass of unclear IA (IA = <NIA, ∅ ,∅ , MVB, VO> ∪ <NIA, ∅ , VIA, MVB; VO>), which can predict the manipulation with internal structure of attribute Classification IA is performed in tables 1 and 2.

Table 1

Classification IA

Rank of intelligent agent	Change of an intelligent agent model				
	NIA	SA	VIA	MVB	VO
Empty	-	-	-	-	-
Nominal	+	-	-	-	-
Parametric	+	+	-	-	-
Passive – cover	+	-	+	-	-
Passive	+	+	+	-	-
Active unclear	+	-	-	+	+
Active terminal	+	+	-	+	+
Active	+	+	+	+	+

If imagine, that the attributes structure SA is a general representation of the knowledge spaces of IA, it is possible to consider this structure on a conceptual level. Most famous work make functional separation of a knowledge of IA (knowledge about the environment, knowledge about yourself, knowledge about other agents and etc. Here "–" means empty condition (∅), "+" means the presence in IA model.

Table 2

Classification IA

<table>
<tr><th colspan="4">Intelligent agents</th></tr>
<tr><td colspan="2">passive
<NIA, SA, {IA}, 0, 0></td><td colspan="2">active
<NIA, SA, {IA}, MVB, 0></td></tr>
<tr><td rowspan="3">Passive cover
<nia, 0, {ia}, 0, 0></td><td>parametric
<nia, sa, 0, 0, 0></td><td rowspan="3">terminal
<nia, sa, 0, mvb, {0}></td><td rowspan="3">Active unclear
<nia, 0, 0, mvb, {0}>
u <nia, 0, {ia}, mvb, {0}></td></tr>
<tr><td>nominal
<NIA, 0, 0, 0, 0></td></tr>
<tr><td>empty
<0, 0, 0, 0, 0></td></tr>
</table>

Functional separation is not universal, because it depends on the features of industry enterprises is related with exact area. Conceptual review allows you to create more General models of intelligent agents as necessary to specify and clarifying the structure of the space of knowledge IA , that related to this intellectual component, as if to form the “near edge” space of the subject area and define its behavior using certain mechanisms of social behavior in this localized group. IA can use the logical mechanism and by methods of consistency, which are located on the intelligent components. Intelligent component will be more resistant structure, “strictly” localized logical and spacely. IA faster, they can move like in a network environmnet. As IA use general mechanism of logical method, then it is not necessary to copy it in every agent, that can increase the action and to reduce memory overhead.

Let’s find an informational space, as a sum of intelligent agents, that surround IA_i and interact with it; a sum of IO, that surround IA_i and interact with it, and a plenty of attributes, which are necessary IA_i to assess the condition of an environment.

$$V_{IA_i} = (AR^i_{IA}, AR^i_{IO}),$$

$$AR^i_{IA} = (N_{IAj}, A^{\xi}_{IA_j}, ..., A^{\psi}_{IA_j}, N_{IAI}, A^{\xi}_{IA_I}, ..., A^{\psi}_{IA_I}),$$

$$AR^i_{IO} = (N_{IOj}, A^{\xi}_{IO_j}, ..., A^{\psi}_{IO_j}, N_{IOI}, A^{\xi}_{IO_I}, ..., A^{\psi}_{IO_I}).$$

Condition of informational space IA_i we call the sum of AR^i_{IA}, AR^i_{IO} in the moment of time – t:

$$SV_{IA_i} = (< A^{\xi}_{IA_j} >, ..., < A^{\psi}_{IA_j} >, ..., < A^{\xi}_{IA_I} >, ..., < A^{\psi}_{IA_I} >,$$

$$< A^{\xi}_{IO_j} >, ..., < A^{\psi}_{IO_j} >, ..., < A^{\xi}_{IO_I} >, ..., < A^{\psi}_{IO_I} >),$$

where <A...> – meaning of attribute in the moment of time *t* from the side of perfomanced intelligent. Information about the condition of informational space IA_i cannot get at the same moment from all the corners of this space, because there is a delay in the exchange of information between agents.

The information space of the agent can be formed in two ways:

a. Static – AR_{IA}^{i}, AR_{IO}^{i} determined at the design stage IA and in the process information management system can't be changed;

b. Dynamic– AR_{IA}^{i}, AR_{IO}^{i} can be changed .

So, informational space model IAi you can find in such way

$$MIS_{IA_i} = (V_{IA_i}(t), SV_{IA_i}(t), FV_{IA_i}(t+1)),$$

where FV – function of formation of information space.

A model of the mechanism of choice behavior of IA can be as follows:

MVB = (MIS, MG, MSR, MA),

where MG – model of goal setting, MSR – model of solution research (direction research, methods how to reach a goal), MA – active actions model, means the activation mechanism of IO, that influences on the environment.

For such IA model of goal setting can be built the next way

$$MG_{IA_i} = (SS_{IA_i}, FSS_{IA_i}, GS_{IA_i}, G_{IA_i}^{top}, G_{IA_i}^{down}, FG_{IA_i}^{D}, FG_{IA_i}^{S}, FAG_{IA_i}, SMA_{IA_i}(t))$$

Then the subscripts can be omitted where it causes no ambiguity. Here SS –plural of stratigies, that means like methods of making choice of an aim $SS = (S_i \,|\, i = 1,...,n)$, FSS – a function selection strategy; GS –plural of static targets, G^{top} – plenty of goals, that got by an IA from the agents with a higher level of the hierarchy, G^{down} – plenty of goals which can be transmitted to IA at lower levels FG^{D} – function of creating the dynamic targets, FG^{S} – selection static target function; FAG – active goals selection function, means goals, taken to implement; SMA – condition of multi-agent environment.

In contrast to existing agent-based models the state of MA places more appropriate to take into account the dynamics of its development, taking into account both past history and expected future. Condition of MA-environment can be viewed from the position of exact intelligent agent IA_i, that's why

$$SMA_{IA_i}(t) = (Pa_{IA_i}(t), Rt_{IA_i}(t), Fu_{IA_i}(t)).$$

Past MA- environment is $Pa_{IA_i}(t) = \bigcup_{0}^{t} (V_{IA_i}(t-1), SV_{IA_i}(t-1))$, means the unification of the information space and state of the totality of previous points in time.

Current condition MA-environment

$$Rt_{IA_i}(t) = (V_{IA_i}(t), SV_{IA_i}(t)).$$

Predictable future condition

$$Fu_{IA_i}(t) = (V_{IA_i}(t+1), SV_{IA_i}(t+1))$$

is an evaluation of the information space and its condition, that was made in exact moment t–1 means at the previous step of IA. And to make this evaluation, it is necessary to have a future function of MA-environment $FP(Rt_{IA_i}(t), MA)$ as a result it will be $Fu_{IA_i}(t)$.

Strategy selection function determines the current strategy of depending on the previous strategy, the state of MA-environment, plenty of currently active goals. So $FSS: s(t) \times SMA \times GA \to s(t)$.

If notice static goals as *gs*, then goals that are taken from other higher agents like *gt*, goals that are taken from lower levels like, how *gd* then relevant plural will be: $GS_{IA_i} = \{gs^i \,|\, i = 1,...,m\}$, $G_{IA_i}^{top} = \{gt^i \,|\, i = 1,...,l\}$, $G_{IA_i}^{down} = \{gd^i \,|\, i = 1,...,k\}$.

Function of creating the dynamic targets be determined by functional transformation $h_{IA_i}^D$ above the condition of MA-environment, by current strategy, be plenty of $G^{AVT(D)}(t)$, $GA(t)$ and a sum of formula with a logic from the first above the elements MA-environment:

$$FG_{IA_i}^D = h^D(SMA_{IA_i}(t), s^i(t), G^{AVT(D)}(t), GA(t), U),$$

where $U = \left\{U^j(SMA(t)) \,|\, j = 1,...,k\right\}$. The result of work $h_{IA_i}^D$ is $G_{IA_i}^{AVT(D)}(t+1)$.

Selection static goals function can be determined by functional transformation above the condition of MA- environment, by current strategy, plenty of static goals at an exact period of time– $G^{AVT(D)}(t)$, plenty of active goals, that were taken to implementation and a sum of formula with a logic from the first above the elements MA-environment:

$$FG_{IA_i}^S = h^S(SMA_{IA_i}(t), s^i(t), G^{AVT(S)}(t), GA(t), W),$$

where $W = \left\{ W^j(SMA(t)) \,|\, j = 1,...,k \right\}$.

The result of work $h_{IA_i}^S$ is $G_{IA_i}^{AVT(S)}(t+1)$.

For effective operation of an intelligent analytics platform, it is crucial to establish timely receipt of reliable information about the actual values of harmful and dangerous factors that are monitored at workplaces. Data base carriers, as well as primary documents in the system of accounting and analysis of this condition can use data on the certification of workplaces at the food production facilities.

It is suggested to choose the XML type for documents storage that makes it possible to use it as a universal language for requests to information repositories. The XML type also allows you to control the correctness of data stored in documents, perform checks on hierarchical relationships within a document, and establish a single standard on the documents structure, the content of which may be various data. This means that it can be used in the construction of complex information systems, in which the information issue exchange between different applications running on the same system is very important.

The organization of the data entry system is adapted to the existing methods of data accumulation [6] in the general work of the intelligent analytics platform. The labor safety service (department) head of the food production facility receives the output.

Conclusion

The task of increasing the safety of labor in industry enterprises is most rationally solved by introducing such components as data elements and intelligent agents into the information and analytical labor protection management system.

Comparative analysis of the main types of agent models in terms of their applicability to the task of building the information and analytical labor protection management system of the industry enterprises has shown that till nowadays there was not developed sufficiently generic model of an intelligent agent that can take into account the hierarchy of intelligent agents in multy-agent system, the structural hierarchy of goals and, at the same time, it would be focused on the technical implementation within the framework of existing technical facilities in information and analytical labor protection management system of industry enterprises.

It is proposed an intelligent agent model in the structure of an information and analytical labor protection management system of power facilities in industry enterprises, which is different due to the way the information space of intelligent agents is formed, the availability of a model for behavior selection mechanism and the contents of intelligent agent's goal definition model, which allows to determine the dynamics of development of multi-agent environment, complicated hierarchy of goals in the information and analytical labor protection management system of power facilities at enterprises and form various operation strategies for intelligent agents.

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