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METHODS OF AGENTS CONTROL IN MULTI-AGENT EXPERT SYSTEM

In the article we discuss the user models interacting with distributed network resource, where every user has a correlated agent, as well as on the methods of multi-agent expert system control.

Keywords: expert system, the agent, interaction, behavior, control.

The administration of distributed network resources requires solving tasks, concerned with the complexity of resource-to-user interaction organization.

To solve the set task [1] the following multi-agent expert system (fig. 1) has been developed.

To organize interaction between users and distributed network resource on a basis of the developed multi-agent expert system model we will consider the following models of agent's behavior coordination [2–6]:

1. Game-theory modes – solve the tasks of selection solutions in conditions of equivocality and conflict, which if followed, allow the constructing of rule sets and conversations, permitting agents to achieve equilibrium agreements.

2. Models of collective behavior for automats – are based on constructing conversation rules and protocols in tasks, which are characterized by a large quantity of simple interactions with indeterminate characteristics.

3. Models of collective behavior planning reveal methods of agent behavior planning (centralized, partially centralized, distributed) for the purpose of making decisions regarding the selection of self-actions in the process of implementing the plans' coordination.

4. Models based on *BDI*-architecture – apply axiomatical methods of the game theory and the artificial intellect's logical paradigm. The task of the agents' coordination behavior consists in coordinating the output results in the knowledge bases of these agents, obtained for the current state of external environment.

5. Models based on competition – imply the "auction" concept as a mechanism of the agents' behavior coordination. The concept is based on a postulate regarding the possibility of undisguised transfer of "usability" from one agent to another, or to the agent-auctioneer.

On the interaction assumption with distributed network resource, the following subpopulations were segregated from the full set of users U: A – administrators subpopulation (fig. 2), E – experts subpopulation, RU – registered users (fig. 3), GU – guest users (fig. 4). Since data regarding candidate users is formed on the base of processing information received from experts, who also have a right to influence all aspects of expert system functioning, the following assumption was made: the authentication of subpopulation U by agents is unviable. We shall build the behavior models for segregated users.

The following agent types were associated with all the user classes: for each guest user GU_i – reactive agent $RAGU_i$ (fig. 5), for each registered user RU_i – reactive agent $RARU_i$ (fig. 6), for each user-administrator A_i – intellectual agent IAA_i (fig. 7).

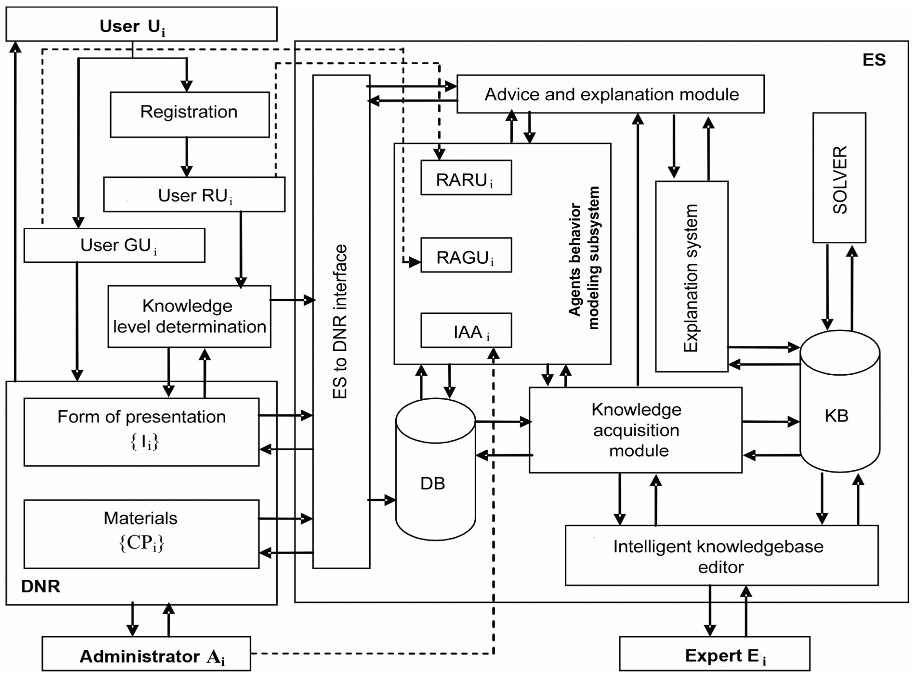

Fig. 1. Model of a multi-agent expert system

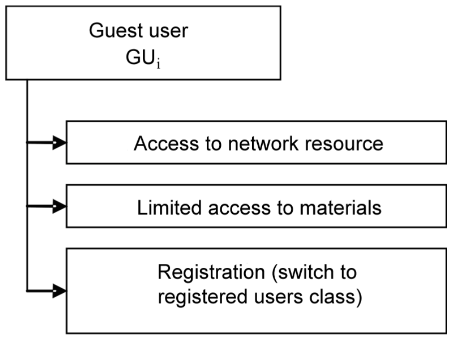

Fig. 2. Guest user behavior model

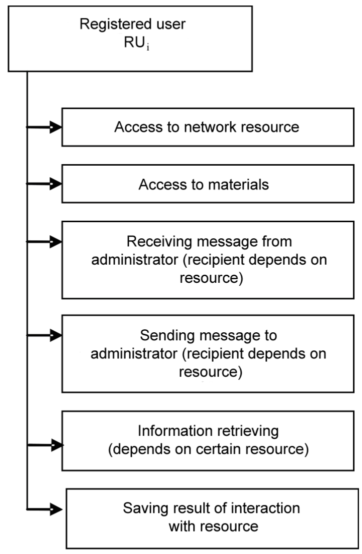

Fig. 3. Registered user behavior model

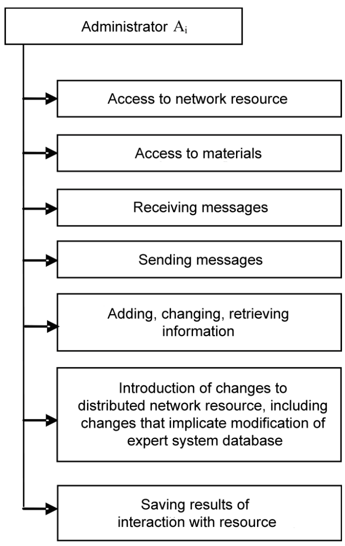

Fig. 4. Administrator behavior model

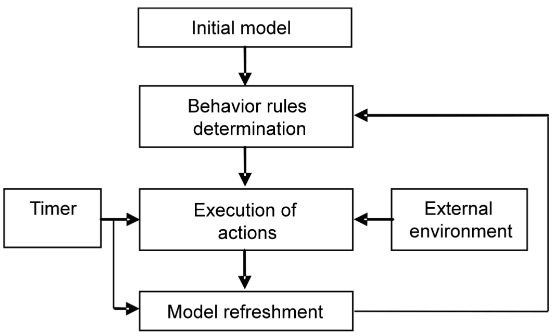

Fig. 5. Model of guest user agent "life cycle"

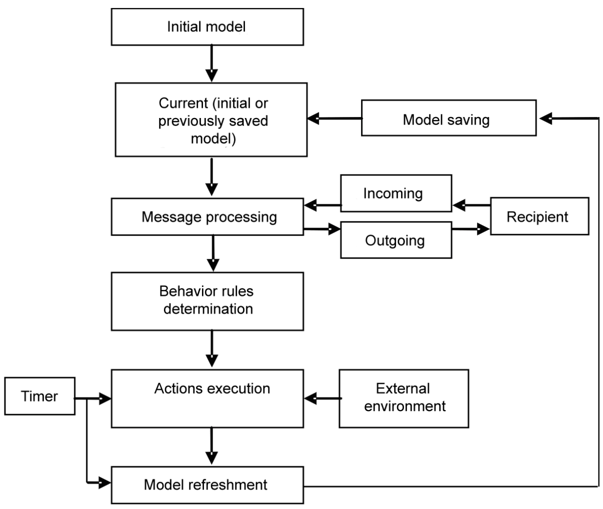

Fig. 6. Registered user agent "life cycle" model

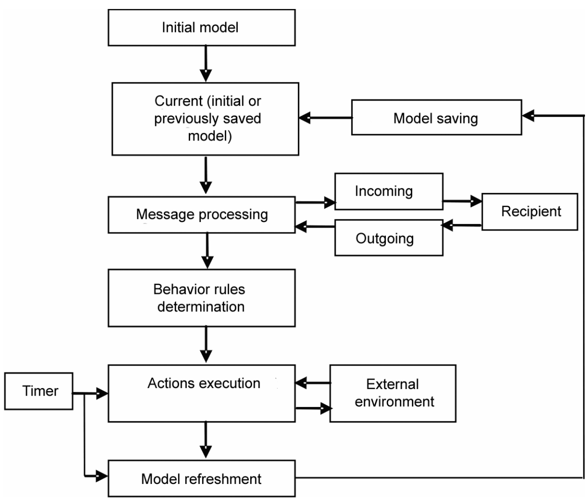

Fig. 7. Administrator agent "life cycle" model

In addition to the interaction with distributed network resource it is necessary to organize relations between existing agents, whose main features are directedness, selectiveness, intensity, and dynamism. It is essential to consider the finiteness of existence time for every agent, and the influence of the agent's behavior within the applied materials, located in a distributed network resource.

We shall consider requirements for agents [2; 3], correlated to each users subpopulation (see table).

Requirements for user agents

Characteristics	Agent type		
	RAGU$_i$	RARU$_i$	IAA$_i$
Independent execution	+	+	+
Interaction with other agents	+	+	+
Reactivity	+	+	+
Adaptive behavior		+	+
Education based on interaction with environment		+	+
Tolerance towards mistakes and/or improper input signals			+
Real-time functioning			+
Life cycle finiteness	+	+	+
Persistence of behavior in expert system DB		+	+

Due to the fact that reactive agents do not possess complex knowledge of the environment and are fully dependent on the objective (used to compose reactions for the designed situations and are also independent and have finitesimal life cycle), we can consider the definition of their functioning based on the production systems with an imperative kernel. In this case every agent possesses a rule set $R = \{r_1, ..., r_i, ..., r_n\}$, which has the following structure:

$$r_i : p_i ; a_i \rightarrow b_i ,$$

here $a \rightarrow b$ – is the kernel, which is the basic component of production and is interpreted as "if *a*, then *b*", *a* – is inference *b* existence conditions ; *i* – name, which allows to identify the present production from the production set; p_i – constraint of kernel production usability (predicate): if *p* – true, the kernel is actuated.

Let us assume that for the reactive agent:

$$a_i = \vee_j \left(\wedge_k a_{ijk} \right),$$

where a_{ijk} – explicit predicate over state *S* of agent $a_{ijk} = a_{ijk}(S)$, $S = \{s_i, ..., s_j\}$, s_i, s_j – state parameters.

Example:

– WHEN user = registered user;

– AND logon to distributed network resource;

– IF unread messages are in presence;

– THEN user is invited to review messages.

Thereat the intellectual agent requires a change in the structure of rules, videlicet the replacement of the kernel with an optional one, having an estimation of implementation on the base of fuzzy logic and introducing the following tail conditions to the structure:

$$r_i : p_i ; a_i \rightarrow b_i ; n_i ,$$

here n_i – are tail conditions for *i* – is production.

Let us assume that for the intellectual agent:

$$a_i(S) = \vee_j \left(\wedge_k a_{jk}(S) \right) \Rightarrow f_{a_i}(S) = \max_j \left(\min_k f_{a_{ijk}}(S) \right),$$

where *f*(*S*) – is the membership function, dependent on predicable truth, as follows: $f_{a_i}(S) = 0 \rightarrow b_i$ – false, $f_{a_i}(S) = 1 \rightarrow b_i$ – true. For definiteness of change in the agent state we shall introduce $f_{cutoffi}$ for which $f_{a_i}(S) > f_{cutoff_i} \rightarrow b_i$ – is true and the tail condition n_i is fulfilled.

Example:

– IF unread messages are in presence;

– AND these are not urgent;

– AND NOT (administrator is busy);

– WHEN with f_{cutoff} = 0,75: offer to show messages to the administrator;

– TAIL CONDITION = show messages to the administrator;

– IF unread messages are in presence;

– AND these are urgent;

– AND NOT (administrator is busy);

– WHEN with f_{cutoff} = 0,1 show messages to the administrator;

– TAIL CONDITION = show messages to the administrator.

Such requirements allow coordinating of the agents' behavior using a model based on *BDI*-architecture, since such concepts as beliefs, desires, and intentions are accentuated. Logical inference in knowledge bases is done directly in the process of agent functioning.

Multi-agent expert system, based on a hybrid architecture, with the use of two types of agents: intellectual, for the administrator subpopulation and reactive, for the subpopulations of registered and guest users, should implement reflexive control over distributed a network resource, the task of which is to make users consciously fall under external influence (i. e. to externalize such desires and intentions, which correspond to the environment).

We understand reflexive control as:

– the actualization of socially significant demands;

– the generation of a set of unique administrative concepts and relations;

– the realization of an activity set, particularly by means of engaging specialists (experts) to take part in the concept interpretation.

The expert system itself is based on the production model with fuzzy logic [7], where the agents' behavior modeling subsystem is used as a potential argument for predicates in antecedent rules, (the observed agents' behavior can be used in the rules of the expert system, but it can only be influenced by environmental change).

Let us assume that S_a – is the agent's state, S_v – is the observed agents state, S_e – is the expert system state, S_r – is the distributed network resource state;

$R_e = \{r_{e_1}, ..., r_{e_i}, ..., r_{e_n}\}$ – is the set of rules possessed by an expert system of type $r_{e_i} : p_{e_i}; a_{e_i} \to b_{e_i}; n_{e_i}$, where $a_{ei}(S_e)$ – is the existence condition for inference b_{ei}, moreover S_e includes S_v ($S_v = \{S_{v_1}, S_{p_{v2}}, ..., S_{v_i}, ..., S_{v_n}\}$), $S_v \subset S_a$ ($S_v \subset S_e$), b_i – are the results of redefinition of S_e, which again can result in redefinition of S_r. As far as S_r can cause change of the user's behavior (this changes environment influencing of the agent's behavior), which, again is observed by the expert system; videlicet behavior of user at a moment of time t_1 (beginning of the expert system operation) results in changes of distributed network resource at a moment in time t_2 and in possible subsequent behavior of user at a moment in time t_3 and so on (Пд – behavior):

$$S_r^{t_n} = \Bigg(S_r^{t_{n-1}}, S_e^{t_{n-1}} \text{Пд}^{t_{n-1}} \Bigg(S_r^{t_{n-2}} \Bigg(S_r^{t_{n-3}}, S_e^{t_{n-3}}, \text{Пд}^{t_{n-3}} \times$$

$$\times \Bigg(S_r^{t_{n-4}} \Big(... \Big(S_r^{t_2}, S_e^{t_2} \text{Пд}^{t_2} \Big(S_r^{t_1} \Big)\Big)\Big)\Bigg)\Bigg)\Bigg)\Bigg).$$

A model of interaction between distributed network resource and users has now been developed. Its main peculiarity is the use of the multi-agent expert system. Methods of agent management allow the rationalization of the present interaction by means of the user's behavior reflexive control via dynamic modifications in the representation and the content of network resource.

On the base of educational the following resource (www.i5nfo.ru) the present methods are applicable for tasks of interaction between organizations, distributed network resources, and the user. They have also been applied to instruments measuring and monitoring radiation levels, which had been affirmed by implementation acts.

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A COMPREHENSIVE EVOLUTIONARY APPROACH FOR NEURAL NETWORK ENSEMBLES AUTOMATIC DESIGN

A new comprehensive approach for neural network ensembles design is proposed. It consists of a method of neural networks automatic design and a method of automatic formation of an ensemble solution on the basis of separate neural networks solutions. It is demonstrated that the proposed approach is not less effective than a number of other approaches for neural network ensembles design.

Keywords: neural networks, ensemble, automatic design, genetic programming, probabilistic evolutionary algorithm.

At the present time data analysis systems which are based on intelligent information technologies are increasingly demanded in many fields of human activity and the scale requirements to these systems are continuously increasing. In connection with these facts the problem of developing methods for automatic design and adaptation of IIT for specific tasks is becoming more urgent. Such methods could allow to abandon the use of expensive, mostly human, resources for the design of the IIT and to reduce the time required for the development of intelligent systems.

One of the most widely used and popular intellectual technologies are artificial neural networks. The range of problems solved by using neural networks is extremely large because of many advantages of systems based on their use. Despite the fact that this information technology could be called a universal tool for solving problems of data analysis, in each case we have to create a unique neural network. One of the approaches to improve the efficiency of systems based on the use of neural networks is the use of neural networks ensembles. Problem solving with the help of neural network ensembles supposes