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Simulation of Actions Exercise in the Unsupervised Training Algorithms of Intelligence Systems at Fuzzy Semantic Networks.

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ABSTRACT

There was elaborated comparative procedure of imprecisely performed relations in the problem environment model that differs from the known ones by the fact that it lets give an unbiased estimate of equality of imprecisely expressed factor, and, consequently, increase comparison accuracy. There were described unsupervised training algorithms enabling to form programs of rational behavior in various problem environments differing from the known ones by simulation of searching actions exercise at fuzzy semantic networks.
Keywords: Intelligence systems, problem environment, fuzzy semantic network, set of points and lines, characteristics, terms, unsupervised training algorithms.

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INTRODUCTION

Creation and perfection of principles for complex objects control, for effective systems for problem solving systems [1] and creation of expert systems [2] on the basis of artificial intelligence modern achievements [3, 4] is one of the most important guidelines of production growth and boost of scientific-and-technological advance. Topicality of the problem under study is confirmed both by tremendous upgrowth of researches in the field of artificial intelligence and by their lively implementation into different fields of human activity. Great contribution to intelligence systems development was made by: Averkin A.N., Bershtein L.C., Vaguin V.N., Efimov E.I., Zhuravlev Y.N., Zaripov A.H., Klykov Y.I., Litvintseva L.V., Levin D.D., Lubarskiy Y.A., Melikhov A.N., Narinjani A.S., Pospelov D.A., Popov E.V., Tymopheev A.V., Fin V.K., Tsalenko M.Sh., Chernukhin Y.V. and al. [5, 6, 7].

METHODS

Formally fuzzy semantic network [8] is an oriented fuzzy multigraph $G_1=(V_1,E_1)$, where $V_1=v_i$ i= 1,n_{-1} and $E_1=e_i$ i=1, n is set of points and lines, respectively. Points $v_i \in V_1$ correspond to problem environment objects bijectively, lines correspond to relations among these objects in the environment. Points $v_i \in V_1$ can be of two types: free v^*_i and occupied v^0_i. Every free (active) point $v^*_i \in V_1$ is determined by set of characteristics X_i, that specified objects $o_{i1} \in O$ can have in order to mark these points with names in the current situation (in-situ) of problem environment. After having been marked, an active point v^*_i becomes passive v^0_i and now it is determined by set of characteristics X_{i1} of a specified object being its mark. Otherwise stated, the active point $v^*_i \in V_1$ is marked by an object $o_i(X_i) \in O$ while meeting the condition $X_i \subset X_{i1}$, where $o_{i1}(X_{i1})$ means that the object o_{i1} is described by a set of characteristics X_{i1}. Lines $e_i \in E$ or objects relations in the problem environment are preset by pairs $<\mu(x_i),T_j>$, where T_j is a fuzzy value (term) of linguistic variable $T_j \in T^*$; $\mu(x_i) \in [0,1]$ – degree of membership of linguistic variable quantitative value $T_j \in T^*$ to the interval of term numerical value T_j; $T^* \subset \{T_j\}$ – set of linguistic variables corresponding bijectively to semantic definition of different relations.

In the studied case, while fuzzy semantic network description, restrictions determined by terms elements are the linguistic variable sets and are put on the basic variables $x_i \in U_i$; they are clearly set and are calculated based on functional purpose and possibilities of intelligence system.

MAIN PART

In order to pass from the quantitative values of relations among problem environment objects measured by informational and measuring system of intelligence system and determined by base values x_i of linguistic variables, to quality values, e.i., to a term T_j, one can use the following transformation:

$$F: i \rightarrow \begin{cases} T_j, \text{ if } 0 \le x_i < x_i^*; \\ T'_j, \text{ if } x_i^* < x_i^{**} \le x_{i+1}^*; \\ T''_j, \text{ if } x_{ik-1}^* < x_{i+1}^* \le x_{ik}^*; \end{cases} \quad (1)$$

where x_i^* and $x_{i+1}^*, i=\overline{1,k}$ respectively, lower and upper limit of numeric values x_i^{**} of term T'_j, $\left[x_i^{**}\right]$ is the middle of numeric values interval for this term; x_{ik-1}^*, x_{ik}^* - respectively, lower and upper limit of numeric values of term T''_j, x_{i+1}^* is the middle off numeric values interval for term T''_j

Degree of membership $\mu(x_i)$ of the basic variable x_i values to set of term T_j numeric values can be calculated by the following formula:

$$\mu(x_i)=\begin{cases}\dfrac{x_i-x_i^*}{x_i^{**}-x_i},\text{åñëè} x_i\in\left[x_i^*,x_i^{**}\right];\\ \dfrac{x_i-x_i^{**}}{x_{i+1}^*-x_i},\text{åñëè} x_i\in\left[x_i^{**},x_{i+1}^*\right]\end{cases}\qquad(2)$$

To compare two interrelation values set by three-digit groups $< x_i, \mu(x_i), T_j >$ and $< x_i, \mu(x_i'), T_j' >$, we will introduce the characteristics of their proximity (relationship) degree $\rho(x_i, x_i')$ that can be calculated as follows:

$$\rho(x_i,x_i')=\begin{cases}\text{a)}\ \ 1,\text{если } (|x_i-x_i'|<\varepsilon_0)\ \&\ (T_j=T_j');\\ б)\mu(x_i)\leftrightarrow\mu(x_i'), если |x_i-x_i'|>\varepsilon_0)\ \&\ (T_j=T')\ \&\ ((x_i,x_i')\in\left[x_i^*,x_i^{**}\right]\vee(x_i,x_i')\in\left[x_i^{**},x_{i+1}^*\right]);\\ в)(\mu(x_i)\leftrightarrow(1-\mu(x_i'))), если |x_i-x_i'|>\varepsilon_0)\ \&\ (T_j=T_j')\ \&\\ \&\ ((x_i,x_i')\notin\left[x_i^*,x_i^{**}\right]\vee(x_i,x_i')\notin\left[x_i^{**},x_{i+1}^*\right]);\\ г)0, если T_j\neq T_j',\end{cases}\qquad(3)$$

where ε_0 - parameter setting the adjusted value of comparison accuracy of the ratio value; x_i' - basic variable to the set of numeric values of T_j' term; $\leftrightarrow$ - operation of fuzzy equivalency determined by formula $\min(\max(\mu(x_i),(1-\mu(x_i'))),\max(\mu(x_i'),(1-\mu(x_i))))$; & - conjunction making simultaneity of the fulfilling conditions.

Expression (3) can be justified as follows. Two quantitative values of the ratio are equal if they are within the numeric values interval of the same T_j term, within the neighborhood of the same point determined by parameter ε_0 value (case a); two quantitative values x_i and x_i' are fuzzily equal if they are within the numeric values interval of the same term T_j. At this, if the both values of degree of membership are within the same half of the term numeric values, degree of congruence is calculated by «б», otherwise, it is determined by «в». x_i and x_i' values are not equal, if they are within the numeric values intervals of different terms of T_j linguistic variable (case г). Let's examine problem environment as set of interconnected objects and events not depending on intelligence system $Q=\{q_{i_1}\}, i_1=\overline{i,n_1}$. In each discrete instant of time t, the environment can be described by the current situation $s_i^t\in S$, being distinguished by the current states of the objects within this environment and by character of relations among these objects. For simulation of actions exercise in the fuzzy semantic network, each of them is determined by the following describing format <<action name><fuzzy semantic network determining acceptable conditions for action exercise ><fuzzy semantic network describing the exercise result>>, we will name it Action Frame (AF).

The first part <action name> is the action ID. The second part <conditions which fulfillment in the problem environment is required for successive action exercise> is an active fuzzy semantic network which formal description is a multigraph $G_1=(V_1,E_1)$, where V_1 – set of free points each of which is marked by list of X_i characteristics, that the object are to have; this is required for acceptable accomplishment of AF action. The third part, AF, <action exercise result> is a fuzzy semantic network got from G_1 network after action exercise of this frame. Simulation of actions exercise is performed as follows. At the first stage, takes place the determination of all the actions that can be performed directly in problem environment according to the contents of the second part and that correspond to AF actions. Then, one selects a specific action for exercise and its exercise simulation occurs in fuzzy semantic network; this simulation determines the current conditions for operation. The fuzzy semantic network determining the current situation of problem environment by the third part contents AF is amended by values of relations between the environment objects received after the direct action exercise in the problem environment. If the action exercise simulation results in situation close to the goal one by its contents, there is formation of a link in the behavior chain under the condition of implicative solving rule $S_{тек}$ & $в_j^1 \rightarrow S'$, where the given record means that at perception of the current problem environment situation $S_{тек}$, action exercise $в_j^1$ results in its transformation to the consequent situation $S'_{тек}$. At this, degree of membership $\rho(S_{i+1тек}, S_{цел}) > \rho(S_{iтек}, S_{цел})$, i.e., b_j^1 action transforms $S_{iтек}$ situation to $S_{i+1тек}$ situation; between the new and goal situations, there is fewer differences than between the goal and initial ones. In consequence, the model $L(x) = S_{T_{i+1}} \& b_j \rightarrow S^2_{T_{i+1}} \& b_{j+1} \rightarrow \ldots \rightarrow S_{T_{i+n}} \& b_{j+n} \rightarrow S_{цел}$ of rational behavior is formed. The behavior model obtained while unsupervised training becomes finally stable by attaining the goal after its direct realization in the problem environment. Let's describe unsupervised training algorithm of an intelligent robot [9] at fuzzy semantic networks. There can be two such algorithms: with active behavior logic, and active and passive behavior logic [10]. Algorithm with active behavior logic is intended for unsupervised training of intelligence system in the static environment. In the algorithm with active and passive behavior logic, the current situation is to be formed first. One watches the situation alteration. If spontaneous alteration occurred in the modified situation, one should form a set of exercised actions and check the condition by simulating the actions exercise: "among them, there are actions leading to goal attaining". If there are no such actions, one should keep watching the environment alteration. Otherwise, one memorize the chain $S_{i\ тек}$ & $b_j \rightarrow S_{цел}$. Further, one takes $S_{цел}$ for $S_{i\ тек}$ by watching the environment alteration. If the process has not attained the goal within the set time interval, one should pass to active logic of behavior.

AFTERWARDS

Process of unsupervised training of intelligence system can be considered as graph automated generation provided that it does not know the results that can be achieved by the actions under exercise. Practical utility is consists in possibility of use of the elaborated algorithms of the rational behavior for unsupervised training of intelligence systems in the really hardly accessible environments for human.

CONCLUSIONS

It was offered an innovative problem environment model as fuzzy semantic network that differs from the known ones by set of points determining events not depending on the intelligence system; it enables modeling dynamic problem environments and assuring simulation of intelligence system unsupervised training in the dynamic environments not being determined completely.

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