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MULTI-AGENT SYSTEM FOR ASSESSING THE STATUS OF WEAKLY FORMALIZED SYSTEMS

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ABSTRACT

In the article discussed a multi-agent system for assessing the status of poorly formalized system. Poorly formalized system consists of multiple agents interacting in a distributed mode. Achievement in the field of distributed artificial intelligence, the theory of intelligent agent technology and soft computing, makes it possible for these agents as components of complex systems interact to cooperate, compete with each other and coordinate their actions in order to develop a global behavior, poorly formalized systems.

KEYWORDS: The Theory of Fuzzy Sets, Fuzzy Logic, Multi-Agent Complex System, Weakly Formalized System, Decision-Making

INTRODUCTION

In complex multi-agent system, motivations, intuition, human knowledge, and human behavior (perception, emotions, and norms, play dominant role. Traditional methods of modeling are not powerful enough to adequately reflect human thinking and behavior related to decision-making. Need a new, much more powerful modeling language for representing reality. Today one of the most promising areas of research in the field of analysis, forecasting and modeling processes is a semi-Fuzzy technology (fuzzy logic, fuzzy sets, fuzzy measures, fuzzy integral calculus). According to Professor L. Zadeh, modeling languages, based on fuzzy logic, is much more suitable for describing realities than their counterparts based on bivalent logic and have considerable potential to play a significant role in modeling the technical, economic, social and political systems.

Tasks related to poorly formalized processes are multifactorial and multidimensional. Conducting field studies is almost impossible, in connection with which there is widespread involvement of modern mathematical models, numerical methods and information technology, which are based on artificial intelligence methods. In this regard, the issues of creating a new class of models, combining features and qualities of uncertainty and their software implementation are very important.

The main reason that the classical theories have not been successful in modeling poorly formalized processes is the fact that these theories are formulated in terms of the natural Sciences, which are exact in nature.

A complex system consists of many agents interacting in a distributed mode. Achievement in the field of distributed artificial intelligence, the theory of intelligent agent technology and soft computing, makes it possible for these agents as components of a complex system interact to cooperate, to compete with each other and coordinate their actions with the aim to establish global behaviour of economic system. Recently great interest in the development of intelligent

agents (Intelligent Agents - IA) and multi agent systems for assessing the status of poorly formalized processes.

It should be noted that agents often deal with incomplete, inconsistent and inaccurate data and knowledge. Agents have to make decisions in conditions of uncertainty, i.e., multi-agent system operates in an environment characterized by uncertainty and inaccuracy.

In the conventional concept of multi-agent distributed intelligent systems, the main idea is granulation of functions and regulatory mechanisms of the Central government between functions and objectives of local agents. These intelligent agents can work together, to cooperate, and be coordinated to achieve a common goal.

An alternative concept of a multi-agent distributed intelligent system with cooperation and competition among agents, different from the classical approach is the following: each intelligent agent acts completely autonomously; each intelligent agent proposes a solution to a common problem (not just their own), every agent has full access to all available information; the General solution is defined as the offer of one of the parallel functioning agents on the basis of competition (not by coordinating and integrating particular solutions of agents often performed iteratively); cooperation of agents also generates the required behaviour of the whole system; actions related to the cooperation and competition in the system are performed simultaneously (not sequentially).

A similar idea is to consider the whole system into agents with cooperation and competition between them is presented in several papers [1-5].

A lot of simulations for different real world processes, including the macroeconomic objectives with the description of the dynamics using fuzzy differential equations, among which the economic problems of supply and demand, national economy, etc., was reviewed by John. Buckley, A. Coverson [6].

The problem of optimal control of a complex dynamic economic system was considered in several works (for example, Solberga and Suen, Zhukovskiy and Salukvadze, etc.) [7-11].

The methods of fuzzy control in problems of stabilization of the economic processes to implement stabilization strategies in an adequate, human-readable key with linguistically described algorithms proposed in the paper V. Georgescu [12].

In recent years numerous papers and several books have investigated the use of fuzzy logic as a tool for creation of intelligent systems of the future in business, Finance, management and Economics [13-16]. In these books presents the latest developments in the application of components of Soft Computing including neural networks of different types, fuzzy logic, chaos theory, etc.

In the book by R. A. Aliev, B. Fazlollahi, R. R. Aliyev presents new developments in practical applications of soft computing in business and Economics [17].

STATEMENT OF THE TASK

Multi-agent computational models are used to simulate the behavior, actions and interactions of Autonomous individuals (called agents) in the system. The purpose of simulation is to assess the impact of the behavior of each agent in the system as a whole. Simulate the actions of each agent allows to reproduce and predict the behavior of the system. It is assumed that each agent acts solely in their interests, increases its economic profit (in economic models), or your social

Statute (at sociological modeling).

It is considered that each agent has limited knowledge about the system. In the modeling process, agents can gain experience, learn and replicate.

Using multi-agent models for social systems began with the work of the programmer Craig Reynolds in which he attempted to simulate the activity of live biological agents (model "Artificial life").

Based on multi-agent models based on three core ideas:

- object-orientation;
- learning agents (or their evolution);
- The complexity of the calculations.

The dominant methodological approach is the approach that calculates the equilibrium or pseudo-equilibrium systems with many agents. Thus, the models themselves, using simple rules of behavior, can give very interesting results, consistent with the goals of the developer.

Multi-agent models consist of dynamically interacting according to certain rules of agents and the environment in which they interact. The environment can be quite complex.

The basic properties of agents:

- Intellectuality. At the same time, this property must be moderate in order that the agents could not know something more, beyond the rules of the game.
- Having life goals. Location in time and space. Sometimes, the result of the interaction of agents in the environment " — a balance that sometimes is a continuous process of evolution, and sometimes — infinite loop with no solution. It is believed that multi-agent simulation complements traditional analytical methods. The latter allow us to characterize the equilibrium of the system, and the simulation allows you to explore the possibility of obtaining such status.

In the simulation there are several paradigms — problem statements and approaches to their solution that is used as a "framework" when you build and analyze models. We can distinguish four differing belief systems: dynamical systems, system dynamics, discrete event simulation and agent-based models.

These paradigms differ not so much applications, how many concepts and views on the problem and approaches to solving the problem. Very often, proponents of one paradigm believe that the "correct" formulation and solution of problems of simulation is possible only in the framework of the concepts and practices of this paradigm. For example, apologists for the modeling and analysis of dynamic systems consider that the other approaches are not exactly scientific; either they are a particular case of reporting and analysis systems in the form of systems of differential-algebraic equations. In fact, each of the paradigms has the right to life, their use is determined only by the purpose of modeling and related target levels of abstraction when solving problems.

Multi-agent approach as a method of imitating modeling is relatively new. Agent-based model represents the real world in the form of a set of active entities, called agents and environments where they live. Each agent interacts with other

agents that are part of the external environment, and in the process of operation can change as the environment and their behavior. Usually in such systems there is no global centralized control, the agents operate under their own laws asynchronously. The task of simulation is to build simple models of complex real systems. This desire should be noted, corresponds to the modern tendencies in an object oriented programming. This contributes to the fact that multi-agent models typically implement software using object oriented paradigm.

There are many definitions of the concept agent. Common in all these definitions is that the agent is an entity that has activity, Autonomous behavior, can make decisions in accordance with some set of rules that can interact with the environment and other agents, and can also change (evolve) and learn on their own. The purpose of agent models is to gain insight into these global rules and the General behavior of the system, proceeding from assumptions of individual, private behaviour of its separate active objects and the interaction of these objects in the system.

Multi-agent models are used to study decentralized systems, which dynamics of functioning is defined not by global rules and laws, but on the contrary, these global rules and laws are the result of individual activity of group members. For example, in Economics, in which the entire organism is formed "bottom-up" is not quite adequate models and descriptions of the steady-state equilibrium regimes. Much more interesting and adequate analysis models to perform the analysis of the formation of the rules and trends of the global behavior of the integral characteristics of the behaviors of many components of active players.

Essence of agent-based modeling in the General case can be divided into two classes: conventional, traditional environment objects that can be considered passive because they expect the message before performing the operation. After the objects are initiated, they perform their function and "sleep" until the next job. Active objects that react to events in your environment, and take certain actions without waiting for a direct appeal to his naturally modeled with agents.

It is obvious that the application of this approach to modeling is most useful in cases when we are interested in the behavior of the whole system, defined as the integral characteristics of the whole population of agents.

There are studies establishing the connection between fuzzy multi-agent approaches. We also proposed to study a method which combines the use of multi-agent systems and fuzzy logic is used as a tool for building fuzzy systems.

MULTI-AGENT DISTRIBUTED INTELLIGENT SYSTEM. THE RULE BASE CONSISTS OF A SET OF FUZZY RULES IS THE MODEL OF AN AGENT AND HAS THE FOLLOWING FORM

$$R_k = IF\ x_1\ is\ A_{k1}\ and\ x_2\ is\ A_{k2}, ..., x_n\ is\ A_{kn}$$
$$Then\ y\ is\ B_k, k = \overline{1,m}$$

Where $x_i, i = \overline{1,n}$ the input variables of the k-th agent, y - th output, A_{ki} and B_k - fuzzy sets that describe the linguistic terms of the input and output variables of an agent.

The main idea of the proposed multi-agent system based on dividing the whole system into cooperative Autonomous intelligent agents. These agents compete and cooperate with each other in order to find solutions to global problems and the synthesis of individual solutions to common problems in the final decision.

Proposed multi-agent distributed intelligent system consists of agents acting on the basis of knowledge. Input

information for all agents represented by five fuzzy variables: $\tilde{x}_1$, $\tilde{x}_2$ and $\tilde{x}_3$. Using the rules of fuzzy inference, each agent generates its output decisions. Fuzzy rules of the knowledge base of each agent are as follows:

For the first agent:

IF $\tilde{x}_1$ HIGH and $\tilde{x}_2$ LOW and $\tilde{x}_3$ AVERAGE, THEN

y HIGH

IF $\tilde{x}_1$ LOW AND $\tilde{x}_2$ HIGH AND $\tilde{x}_3$ AVERAGE, THEN

y AVERAGE

IF $\tilde{x}_1$ AVERAGE AND $\tilde{x}_2$ AVERAGE AND $\tilde{x}_3$ AVERAGE, THEN

y HIGH

For the second agent:

IF $\tilde{x}_1$ HIGH AND $\tilde{x}_2$ LOW AND $\tilde{x}_3$ LOW, THEN

y HIGH

IF $\tilde{x}_1$ LOW AND $\tilde{x}_2$ HIGH AND $\tilde{x}_3$ LOW, THEN

PRICE AVERAGE

IF $\tilde{x}_1$ AVERAGE AND $\tilde{x}_2$ AVERAGE AND $\tilde{x}_3$ LOW, THEN

y HIGH

FOR THE THIRD AGENT:

IF $\tilde{x}_1$ HIGH AND $\tilde{x}_2$ LOW AND $\tilde{x}_3$ HIGH, THEN

y LOW

IF $\tilde{x}_1$ LOW AND $\tilde{x}_2$ HIGH AND $\tilde{x}_3$ HIGH, THEN

y LOW

IF $\tilde{x}_1$ AVERAGE AND $\tilde{x}_2$ AVERAGE AND $\tilde{x}_3$ HIGH, THEN

y LOW

FOR THE FOURTH AGENT:

IF $\tilde{x}_1$ HIGH AND $\tilde{x}_2$ LOW AND $\tilde{x}_3$ LOW, TO

y HIGH

IF $\tilde{x}_1$ LOW AND $\tilde{x}_2$ HIGH AND $\tilde{x}_3$ LOW, THEN

y LOW

IF $\tilde{x}_1$ AVERAGE AND $\tilde{x}_2$ AVERAGE AND $\tilde{x}_3$ LOW, THEN

y AVERAGE

CONCLUSIONS

In this work, we have investigated two concepts of the creation of multi-agent systems: classic, in which the main idea is to separate the functions, powers and regulation mechanisms between the local agents; and the alternative, in which agreement is reached through cooperation and competition among agents. In both cases, it was suggested that coordinated the adoption of optimal solutions.

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