CONTROL IN SOCIAL ECONOMICAL SYSTEMS

Agent Technologies of Market Modeling

Yu. A. Ivashkin

Moscow State University of Applied Biotechnology, ul. Talalikhina 33, Moscow, 109316 Russia

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Abstract—The paper is devoted to multiagent simulation of large active systems of any physical nature such as productive, technological, social, marketing, and biological systems, etc. The formalized description of an intelligent agent modeling of the behavior of an active element in different situations of interaction with other active elements and the environment is considered, as well as structural parametric description of a multiagent simulation model of a large active system.

The state of the multiagent system $\text{Agents} = \{\text{Ag}_1, \text{Ag}_2, \ldots, \text{Ag}_n\}$ with the set of intelligent agents $\text{Ag}_i \in \text{Agents}$ is defined a priori by a known set of vectors of parameters $[3, 4]$ of the intelligent state $\text{Ag}_i$ of each agent that describes agent’s thesaurus, completeness and depth of the knowledge base, hierarchy of ideas and the set of conceptual models of their achieving as given by

$$\text{Ag}_i = \{B_i, G_i, PL_i, Sn_i, Ev_i\}; \quad i = 1, n .$$ (0.1)

where $B_i = \{b_{i1}, b_{i2}, \ldots\}$ is the knowledge base of $i$th agent, $b_j$ is $j$th knowledge domain, $G_i = \{g_{ik}, g_{ik} \ldots\}$ is the set of goals $g_{ik}$ (the $k$th goal of the $i$th agent), $PL_i = \{p_{i1}, p_{i2}, \ldots\}$ is the base of models (plans) of the behavior $p_{ikl}$ ($l$th plane of achieving the $k$th goal of the $i$th agent), $Sn_i = \{p_{i1}, p_{i2}, \ldots\}$ is the structure of intentions (algorithms and procedures $p_{ik}$ of the behavior of the agent $\text{Ag}_i$ for achieving the goal $g_{ik} \in G$), and $Ev_i = \{Ev_i(\text{ag}_1), Ev_i(\text{ag}_2), \ldots, Ev_i(\text{ag}_n)\}$ is the description of external relations with other agents interacting with $\text{Ag}_i$.

At each stage of interaction, the $i$th agent $\text{Ag}_i$ chooses or corrects the goal $g_{ik} \in G_i$ and composes the plan of actions $p_{ik}$ selecting from the library $PL_i$ the models corresponding to the description of the goal $g_{ik}$. Each $l$th model of the plane of achieving the $k$th goal of the $i$th agent $\text{Ag}_i$ is represented as the procedure $p_{ikl}$ with formal parameters

$$p_{ikl} = \{\text{name}_{ik}, \text{args}_{ik}, \text{body}_{ik}, \text{constr}_{ik}, \text{precodes}_{ik}\} .$$ (0.2)

where $\text{name}_{ik}$ is an identifier of the $l$th procedure of achieving the $k$th goal, $\text{args}_{ik}$ is a list of state variables of the $l$th model, $\text{body}_{ik}$ the procedure of the $l$th strategy of achieving the $k$th goal, $\text{constr}_{ik}$ is a list of factors of

The Dynamics of behavior of an active system is unknown, incomplete, imprecise or wrong.
action at the elements of the body of the procedure. \textit{pre-conditions} is a list of conditions for executing the body of the procedure of the \textit{lth} strategy of achieving the \textit{kth} goal.

However, as it was mentioned in [2], practical development of multiagent systems is a complicated problem due to the difficulties in creating virtual environments of agent functioning and the agents themselves. In view of this, in this paper some possibilities of overcoming these difficulties are proposed, using the universal simulation system with object-oriented language for the simulation of the state and agents behavior, means of their communications and interactions, experimental environment, and results processing.

1. STATEMENT OF THE PROBLEM

The goal of this work is to develop agent-oriented simulation models and their program implementations in universal simulation environment in the form of particular operations and procedures of processing data on state of active elements of the system, alternatives and strategies of goal-aimed actions of agents under changing conditions in discrete time periods (time events). Each operation corresponds to its own algorithmic and program unit that provides obtaining the information and accumulating the knowledge of agents about the environment and about the interaction medium, relation to the mechanism of interaction, analysis of the own state and of the state of counter-agents, taking autonomous decisions and the choice of strategies.

The main factor defining the behavior of an agent is the expected reaction as a response to his actions. Thus, any model of active system must contain a scheme of response actions of each agents to the reaction of the partner agents and counter-agents caused by the change of its position in the active environment.

2. THE METHOD OF SOLUTION

The dynamics of multiagent model is defined by the set of realizable strategies of the agents and is represented by a sequence of time-dependent and conditional events under possible reactions of confronting or interacting parts. Identification and prognosis of the state of a large active system of any physical nature is achieved by using of agent technologies of simulation of interaction of intelligent agents by means of negotiations in form of propositions and counter-propositions. The \textit{strategy of negotiation} defines the tactics of negotiation with the estimate of the result and with making the decision at each step of negotiation taking into account changing conditions defining the region of admissible outcomes and separated into \textit{strict and flexible constraints}.

\textit{Strict constraints} are functionally related dependencies between the variables of state and the goal functions, setting the threshold values of the results, which cannot be relaxed. In contrast to this, \textit{flexible constraints} define a set of admissible boundary values of the results and can be relaxes if necessary with different degree of flexibility.

The foundation of the construction of simulation models of intelligent agents in the observed factor space is the initial knowledge database and parametric description of system (0.1) systematized as a \textit{structural parametric matrix model} [1]. In this model, the main diagonal consists of the vector of change of the parameters of state and goal of the agents, the relations between the system elements and the environment are ordered row-wise (see Table).

In the table, \(\Delta G\), \(\Delta g\), and \(\Delta E\) are the vectors of change of the agents state, goal functions, and environment, \(\|\varphi_i\|n\) and \(\|\varphi_j\|n\) are the operators of direct and inverse influence of the change of the state of the \(i\)th agents to the reaction of the \(j\)th agent \(\Delta g_i\); \(f_{ij}\) and \(f_{ji}\) are the sign coefficients or the procedures of influence of the change of the goal function \(\Delta g_i\) of the \(i\)th agent to the change of the goal of the \(j\)th agent,

\[
\Delta G = \sum_{j=1}^{n} w_j \sum_{i=1}^{n} f_{ij} \Delta g_i
\]

is the decomposition of deviation of the common goal \(G\) to the deviation of particular goal of the agents \(g_1, \ldots, g_n\); and \(\|\varphi_i\|n\), \(\|\varphi_j\|n\), \(|f_{ij}|\), \(|f_{ji}|\), \(|0|\) are the matrices of operators of functional relations between the time-dependent agents states, common and particular goals, factors of the environment.

In extended form the elements outside of the diagonal and blocks express known characteristics between the agents and the factors of the environment such that

\[
\Delta A_j = \sum_{j=1}^{n} \|\varphi_j\|n \Delta A_j, \quad j = 1, \ldots, n, \quad j \neq i, \quad (2.1)
\]

and each the \(i\)th row orders the characteristics of influence of the \(n\)th factor space to the \(i\)th factor (\(i\)th agents), and each the \(j\)th column orders the directions and estimates of the action of the \(j\)th factor (agent) to other factor and elements of active environment.

Structural parametric model of the system state allows detailing the description of the state variables and the dynamics of the competing agents, and it also allows defining the structure of the multiagent simulation model with multiple agents interrelated in order to achieve the common global or local goals. The interaction between the agents is made by using of sensor adjoint parameters or directed messages in current events, and the simulation multiagent model of the system will play the transitional processes of its behavior and the states for different discussion, situational, and intelligent agent strategies.

\textit{Program description of the models}, intelligent agents and multiagent systems is written in object oriented algorithmic language for model description.