International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-12, October 2019

Multiagent Models for Forecasting and Identifying Production Processes

Evgeny Anatolevich Nazoykin, Ivan Germanovich Blagoveshchensky

Abstract*: *The article is devoted to the method for creating multiagent models for forecasting and identifying production processes using a structural parametric approach. Using multiagent simulation allows reflecting the state and dynamics of complex active systems of production processes with analysis and forecasting of the quality of the finished product. The methods and algorithms of the structural parametric approach to the implementation of an agent-based simulation model based on the system self-diagnosis are described.

Keywords*: *agent modeling, multiagent technologies, identification, forecasting, food production, production process, modeling, mathematical model, structural parametric modeling, active system, grand system.

I. INTRODUCTION

The dynamics of a grand active production system behavior in most cases exist under the conditions of uncertainty of its intermediate states. The identification and forecasting of the intermediate states of such a system over time is a difficult task that cannot be initially predicted analytically, since it is the result of a multistep interaction between many active elements (production stages) of the system and disturbance effects. Therefore, agent-based technologies can be used to identify and predict various situations in grand active systems in order to simulate the interaction between agents that change their properties and behavior depending on the state of other elements and external influences. Models of agents are abstractions with step-by-step behavior that changes its state characteristics. Such elements combined into a multi-agent simulation model of the active system reproduce the dynamics of the interaction between agents with the ability to identify and forecast the state of the entire system.

II. METHODS

A. General description

It is convenient to use the structural parametric principles of system decomposition as a method for creating descriptions of intelligent agents. The structural parametric model of the multiagent system will be represented by a tuple of agents (Ag_i) in this case.

Revised Manuscript Received on October 30, 2019.

***** Correspondence Author

Evgeny Anatolevich Nazoykin*, Moscow State University of Food Production, Moscow, Russia.

Ivan Germanovich Blagoveshchensky, Moscow State University of Food Production, Moscow, Russia.

The change in the state ΔAg_i of the *i*-th agent, due to its reaction to the current situation and the actions of other agents, can be estimated by some integral criterion Ψ_i, which reflects the change in the state and parameters of the agent in the current situation in the *k*-th time period from their values in the previous *k-1st* period or initial state:

$$\Psi = \sqrt{\sum_{j=1}^{m} w_{ij} \left(\frac{x_{ij}^{k} - x_{ij}^{k-1}}{x_{ij}^{k}}\right)^2}, \quad (1),$$

where x_{ij}^{k}, x_{ij}^{k-1} , are the changes in the *j*-th factor x_{ij} of the state of the i-th agent in the *k*-th and *k-1*st period; and

w_{ij} is the weighting factors for the deviation of the j-th factor provided that

$$\sum_{j=1}^{m_i} w_{ij} = 1 \quad (2).$$

Then the diagonal matrix of changes in the state of agents ΔAg, their goals Δg, and external factors ΔEv in a specific situation, multiplied by the matrix of relations between them, is a structural parametric situational model of a multiagent system at the next step to achieve the common goal G [1].

Main goal	Local goals	Agents	External influence
ΔG	$w_1\cdot\Delta g_1 \quad w_2\cdot\Delta g_2 \quad \cdots \quad w_n\cdot\Delta g_n$	$\|0\|$	$\|0\|$
$\|0\|$	$\begin{matrix}\Delta g_1 & f_{12}\cdot\Delta g_2 & \cdots & f_{1n}\cdot\Delta g_n\\ f_{21}\cdot\Delta g_1 & \Delta g_2 & \cdots & f_{2n}\cdot\Delta g_n\\ \cdots & \cdots & \ddots & \cdots\\ -f_{n1}\cdot\Delta g_1 & f_{n2}\cdot\Delta g_2 & \cdots & \Delta g_n\end{matrix}$	$\begin{matrix}\varphi_{11}\Delta Ag_1 & 0 & \cdots & 0\\ 0 & \varphi_{22}\Delta Ag_2 & \cdots & 0\\ \cdots & \cdots & \ddots & \cdots\\ 0 & 0 & \cdots & \varphi_{nm}\cdot\Delta Ag_n\end{matrix}$	$\|0\|$
$\|l_{ij}\|\cdot\Delta G$	$\begin{matrix}\varphi_{11}^{-1}\Delta g_1 & 0 & \cdots & 0\\ 0 & \varphi_{22}^{-1}\Delta g_2 & \cdots & 0\\ \cdots & \cdots & \ddots & \cdots\\ 0 & 0 & \cdots & \varphi_{nm}^{-1}\Delta g_n\end{matrix}$	$\begin{matrix}\Delta Ag_1 & \|\varphi_{12}\|\cdot\Delta g_2 & \cdots & \|\varphi_{1n}\|\cdot\Delta Ag_n\\ \|\varphi_{21}\|\cdot\Delta Ag_1 & \Delta Ag_2 & \cdots & \|\varphi_{2n}\|\cdot\Delta Ag_n\\ \cdots & \cdots & \ddots & \cdots\\ \|\varphi_{n1}\|\cdot\Delta Ag_1 & \|\varphi_{n2}\|\cdot\Delta Ag_2 & \cdots & \Delta Ag_n\end{matrix}$	$\|t_{ij}\|\cdot\Delta Ev_j$
$\|0\|$	$\|0\|$	$\|0\|$	$\begin{matrix}\Delta Ev_1 & \cdots & \cdots\\ \cdots & \ddots & \cdots\\ \cdots & \cdots & \Delta Ev_n\end{matrix}$

Where ΔAg, Ag, ΔEv are the vectors of changes in the state of agents, objective functions and external disturbance;

φ_{ij}, φ_{ij}^{-1} are the direct and feedback functions of state changes of the *i*-th agent ΔAg_i and its local goal Δg_i;

$\|\varphi_{ij}\|^n$, $\|\varphi_{ij}^{-1}\|^n$ are the operators of the direct and reverse influence of the state change of the *i*-th agent ΔAg on the reaction of the j-th ΔAg_j;

ΔG is the decomposition of deviations of the common goal G into deviations of the local goals of Ag_i agents;

||0||, $\|l_{ij}\|$, $\|t_{ij}\|$ are the null operator and the operators of relations of agents with indicators of the common goal and external influences; and

f_{ij} and f_{ji} are the sign functions or procedures for the influence of the objective function Δg_j of the *j*-th agent on the change in the local goal of the *i*-th agent presented in Table 1.

Table 1: Sign functions of relations of agents.

k	f_{ij}	f_{ji}	Situation
1	+1	+1	Mutual consent and interaction
2	+1	-1	Consent on the one side and opposition on the other side (one-sided conflict)
3	-1	+1	
4	-1	-1	Mutual two-sided conflict
5	+1	0	One-sided positive attitude with indifference on the other side
6	0	+1	
7	-1	0	One-sided negative attitude with indifference on the other side
8	0	-1	

Elements and blocks of the situational model of a multiagent system reflect the change in the state of agents with common global and local goals and the operators of functional relations with ordering of all factors of influence on the *i*-th agent in rows, and the effects of the *j*-th agent on other agents and external influences – in columns.

The structural parametric model of a multiagent system defines a set of state variables and interaction operators of agents united by common global and local goals. It also allows formalizing the algorithms for identifying and forecasting changes in the states of the active system at each simulation step.

B. Algorithm

The algorithm for identifying the state of a multiagent system is reduced to identifying agents whose state led to a deviation from the common goal or approaching it at the first stage, and then to determining the causal factors of the anomalous state of the agents themselves at the second stage.

The algorithm for forecasting the state of a multiagent system is associated with identifying the consequences of a change in the state of any ΔAg_k agent on the development of the situation and the achievement of a common goal.

The specified deviation of the *k*-th agent is recorded in arrays of intermediate and final consequences Sl_l ; l = 1,n and their indices t_l; l = 1,n with subsequent calculation of the elements of the *k*-th column of the situational matrix as follows:

$$S_{ik} = C_{ik}\cdot\Delta Ag_k; i = 1, n \qquad (3)$$

and finding the maximum modulo investigative effect q = i_{max} for the *q*-th agent in it.

III. RESULTS

Further, similar to the previously described algorithm for forecasting the state of an agent, at max = 0, a change in the state of the *k*-th agent has no consequences in the simulated multiagent system, and the cause-and-effect identification procedure ends with the registration of the main possible investigative chain of changes in the states of related agents and their indices t_j.

At max ≠ 0, the index of the maximum influence of the previous (*k*-th) agent on the next one is written to the index array t_l and checked for looping, after which the forecasted change in the state of the *q*-th agent $\Delta Ag_q = C_{qk}\cdot\Delta A_{gk}$ is found (diagonal element of the *q*-th row of the matrix Sij) with a further repetition of the procedure for finding max in the *q*-th column for k = q and $\Delta Ag_k = \Delta Ag_q$.

In order to determine all the consequences of the predicted state of the multi-agent system, the described procedure is included in the cycle of their sequential enumeration according to the principle of unwinding and winding the thread in the final maze [2-4]. When the last agent reaches the selected interaction chain, its last link is interrupted with a return to the previous *k*-th agent k = t_{l-1} and finding the other greatest influence of the state change of the *k*-th agent, i.e., another branch of influence. The procedure stops when returning to the original agent, i.e., when l - 1 = 0.

In the case of a change in the state of m agents ΔAg_i; i = 1, m, the situational matrix model of the forecasted state of the multiagent system is formed sequentially for all initial deviations of the state of the given agents.

IV. CONCLUSION

The method for presenting a multiagent model using the structural parametric approach can be used to identify and forecast grand active systems, which are food production. The presented approach allows to identify the hidden factors that influence the production process as part of the concept embedded in the model and introduce corrective actions to optimize the production process.

REFERENCES

1. Yu.A. Ivashkin, E.A. Nazoykin, "Modelirovaniye sistem. Strukturno-parametricheskiye i agentno-oriyentirovannyye tekhnologii [Modeling systems. Structural parametric and agent-oriented technologies]: laboratory workshop", Moscow: MGUPB, 2010.
2. E.A. Nazoykin, R.R. Naumov, "Analiz proizvodstvennykh protsessov pishchevykh proizvodstv s ispolzovaniyem agentnykh tekhnologiy" [Analysis of production processes in food production using agent technologies] In the collection*: Current state and prospects for the development of packaging in the food industry. Proceedings of the conference with international participation*, 2018, pp. 146 – 150.
3. R.R. Naumov, E.A. Nazoykin, I.G. Blagoveshchensky, M.M. Blagoveshchenskaya, Primeneniye agentnykh tekhnologiy v analize proizvodstvennykh protsessov pishchevykh proizvodstv [Using agent technologies in the analysis of production processes in food production], In the collection: *Advanced food technologies: state, trends, growth points. Collection of scientific papers of the 1st research-to-practice conference with international participation*, November 29 – 30, 2018, pp. 711 – 715.
4. E.A. Nazoykin, I.G. Blagoveshchensky, "Identifikatsiya proizvodstvennykh protsessov s ispolzovaniyem metodov imitatsionnogo modelirovaniya" [Identification of production processes using simulation methods], In the collection: *Current state and prospects for the development of packaging in the food industry. Proceedings of the conference with international participation*, 2018, pp. 97 – 102.