ISSN 2348-1196 (print)
International Journal of Computer Science and Information Technology Research ISSN 2348-120X (online)
Vol. 10, Issue 2, pp: (107-110), Month: April - June 2022, Available at: www.researchpublish.com

Models and methods of coordinated control in multi-agent systems

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DOI: https://doi.org/10.5281/zenodo.6778340

Published Date: 29-June-2022

Abstract: **The problem system analysis of models and methods coordinated management in multi-agent systems is formulated. This systems are intellectual active systems. Matter of theory multi-agent systems are uncovered. Character of methods coordinated management is presented as totality of formalize and not formalize methods of system analysis. Basic classis of conduct models in systems man–machine of coordinated management and adoption decisions are presented. Fuzzy algorithms are elaborated, which are realizing of group by investigation of operations with computers and model of conduct of intellectual active system. This system is interactive system man-machine of modeling coordinated optimization in diffuse conditions.**

Keywords: **system analysis of problems coordinated management, coordinated management, intellectual active systems, multiagent systems.**

1. INTRODUCTION

The problem considered in this paper is the improvement of control and decision-making in complex systems using the theory of control, decision-making, methods and algorithms of intellectual support and computers, which are related to tools. In complex management systems, personnel use their own behavior models (management and decision-making) and their own tools. In our country, these models were formed in the Soviet and post-Soviet periods (most often in the shadow business structure, in the process of business games). This led to the negative attitude of the management and personnel of most complex systems to this problem. The situation can be changed only by a systematic analysis of models of behavior, control and decision-making in complex control systems.

Methods of coordinated control in vague conditions

The system analysis of the problems of coordinated control under the conditions of using information of different physical nature is reduced to the system analysis of coordinated control and coordinated optimization in vague conditions. The latter, in turn, involves the synthesis of formal procedures of game theory, the foundations of the mathematical theory of active systems, control theory, operations research, decision theory, as well as applied mathematics and informal procedures. Informal procedures include ideas and language models of management theory, operations research, decision theory, social and economic sciences, economic statistics, economic analysis, sociology and psychology, social psychology, labor psychology, psychology of will, psychology of motivation and motives, psychology of emotions and feelings, psychology of communication, psychology of influence. Of particular importance are the models of coordinated management in the practice of labor activity, including management and managerial decision-making.

The synthesis of formal and informal procedures is carried out through the application of the concept of vagueness, which combines fuzziness, randomness, fuzzy statistics and statistical fuzziness; vague concepts, judgments, assumptions and beliefs. Also applied are fuzzy and inductive logic, algebra of logic, logic of goals and logic of beliefs in vague conditions, plausible reasoning and decision making in fuzzy and vague conditions; measurement, description and processing of subjective information. The synthesis begins with the development of description models that have formal

and informal components, and models for describing estimates of the effectiveness of solving problems of consistent control and consistent optimization under vague conditions.

The synthesis is carried out using computer models for solving control problems. The basis of such problems are various variants of description models with variable parameters and a computer experiment. To implement description models and computer experiments, methods of mathematical and network programming, analysis and synthesis of complex systems, choice theory, etc., methods of measuring, describing, using and processing subjective information are used. Computer models of coordinated control and coordinated optimization, fuzzy algorithms and vague algorithmic prescriptions for computer experiments are being developed. Comprehensive utility assessment under fuzzy conditions and interactive multivalued utility assessment using fuzzy ratios are carried out.

System analysis of the problems of coordinated control in the conditions of using information of various physical nature is implemented by intelligent information control systems for solving the problems of coordinated control [1, 2]. They include management and its environment (a subsystem of organizational management and managerial decision-making), a researcher or an operations research group, a computer model and a human-machine simulation system (computer experiment).

The method of coordinated control under fuzzy conditions [3] consists in combining formal optimization procedures, heuristic procedures for matching in fuzzy conditions (fuzzy algorithms and fuzzy algorithmic prescriptions), computer experiment and soft calculations, heuristic procedure of fuzzy and fuzzy method evaluation. The method should provide new knowledge, a specific information technology and the usefulness of the solutions obtained using this technology (that is, be better applied and be useful in practice). System-forming methods are the concepts of system analysis, which correspond to the names of the classes of methods.

At present, the following classes of methods can be distinguished [3].

1. Methods for combining formal and heuristic procedures of management theory, active systems theory, operations research and decision making and procedures used in management practice and management decision making.

2. Methods combining methods of the first class and certain ideas of the humanities chosen by the researcher or group of operations.

3. Methods based on the description (with the help of a system analysis of coordinated management in vague conditions) of solving actual problems and tasks of the humanities.

4. Methods based on the use of models of coordinated behavior, that is, models of behavior in human-machine systems of coordinated control and decision-making systems, models of behavior in multi-agent systems.

5. Methods of system analysis of coordinated optimization in vague conditions of behavior models in multi-agent systems.

Models of behavior of intelligent active systems and its agents

Behavior models can be built both by agents themselves and by an operations researcher or an operations research group [4]. The operations researcher applies the principle of complementarity of synergistic artificial intelligence, which involves combining models and methods of different levels of formalization, as well as tools for their study. The reliability of research results is replaced by estimates of their usefulness. In addition to the game theory and decision theory used in active systems theory, a system analysis of decision-making problems is used, which combines both formal and informal procedures.

A holistic teleological concept of purposeful behavior is applied as the basis for selecting, processing, analyzing and interpreting information to extract semantics and build behavior models. This is due to the fact that human behavior is studied by psychologists, social psychologists, anthropologists, sociologists, political scientists, philosophers, psychiatrists, management specialists in social and economic systems. However, their approaches and concepts are different and often irreconcilable. This makes it impossible to combine them into one direction and use them in behavior modeling. In contrast to them, a holistic teleological concept of purposeful behavior gives a complete picture of human behavior that does not contradict the ideas of the theory of active systems.

On this basis, a fuzzy description of such components of behavioral models of purposeful systems as models of choice situations, models of progress towards tasks, goals and ideals, models for analyzing problem situations, models of creative processes and communication of agents has been developed.

Synergetic models are considered, as well as methods and technologies for their identification, construction and transfer to purposeful agents of intelligent active systems. For example, models of agents' behavior were constructed taking into account subjective ideas about the situation of choice [1, 4, 5].

For a fuzzy description of the behavior of an intelligent active system as a whole and for aligning the behavior models of agents, methods of system analysis of consistent optimization in vague conditions were used.

The use of neurolinguistic programming methods provides measuring tools and methods for transferring knowledge about models for modeling behavior. These are, first of all, the concepts of the human representational system, the deep and surface structures of the data of his nervous system, language models, the measurement of feelings and beliefs. Neuro-linguistic programming provides a methodology for organizing experimental research, a technology for collecting and processing data, building multi-level behavior models on their basis and transferring knowledge about them to trained specialists.

To analyze the problems of safety and survivability of an intelligent active system associated with the heterogeneity of agents and the distant (beyond the feelings of agents) future, the main models of spiritual and moral behavior were considered. Their analysis showed that these models are models of purposeful behavior, which include both material and spiritual components of the model. Their construction is based on the principle of open information management.

System Analysis of the Problems of Controlling the Behavior of Agents of an Intelligent Active System

Let us introduce into consideration synergetic models of material and spiritual purposeful behavior [4]. Synergetic behavior models combine all the advantages of the considered models.

From a psychological point of view, the brain has several levels of information processing. The higher numbered level determines the lower numbered levels.

1st level. Environment and context: country, region, market, organization, etc.

2nd level. Behavior: actions and results (material and spiritual). Results - needs, results - motives, results - sanctions. The results of purposeful advancement are tasks, goals and an ideal (material, which determine the quality of life, and spiritual, which determine the safety of life).

3rd level. Abilities and properties: intellectual, cognitive, linguistic, behavioral.

4th level. Feelings, material and spiritual values, beliefs and faith as a set of emotionally colored beliefs.

5th level. Identification: nationality, class, property status, profession, attitude to power, age category, etc.

6th level. Spirituality: communication and intersubject feelings of agents. Spirituality of warring, cooperating, cooperating, competing, competing or indifferent parties. This is the level of agreement or disagreement of all components of the model of an intelligent active system or the level of alignment of agent behavior models.

A real multi-level model of purposeful material and spiritual behavior is described for the past, present, near and distant future with the help of plausible reasoning (concepts about the elements of the model, judgments about their properties and relations, about relations between levels, conclusions about values and beliefs, about identification and spirituality) and inductive logic. A soft computing toolkit has been developed for fuzzy estimation of the probability of the plausibility of these reasonings and their analysis using the parameters of distributions of membership functions.

Synergetic behavior models are formed by the operations research group in the process of interactive system analysis of behavior using language behavior models (patterns). Their structuring into elements and components is carried out in accordance with the objectives of the study. Linguistic, logical, mathematical formalization of these components, construction of representative and computer models of behavior are carried out. Fuzzy algorithms have been developed that are implemented by the operations research group using computers, the formation, alignment and analysis of models of purposeful behavior of agents and the behavior model of an intelligent active system. The latter is an interactive human-machine system for modeling consistent optimization under vague conditions.

The principle of open information management

Consider a two-level multi-agent (active) system with several agents and an information management center. The agent informs the evaluation center of s parameters of his choice situation model (for example, the type of agent) rOW, and the center generates and sends to the agent a message xOX with information about the methods of action, messages uOU with instructions, motivation, and arguments. These messages are informational control actions of the center and change the parameters of the agent r(u). The interests of the agent and the center are expressed by their objective functions f(x, y, r(u))=j(x, y*(x, r(u))) and F(x, y, r(u))=Y(x, y*(x, r(u))).

The solution of such problems involves the development of methods

- identification and construction of models of situations of choice of control decisions of purposeful subjects on the basis of retrospective, current, expert and subjective information;

- coordinated optimization of ideas of purposeful subjects about situations of choice of control decisions;

– generation and display of messages about situations of choice of control decisions by purposeful subjects and methods of managing these messages.

In addition, there is the possibility of developing organizational networks and communication scenarios, as well as the interaction of purposeful subjects in the process of making managerial decisions.

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