Opinion
Open Access

Cooperative robotics in system-informational culture ergonomics

Abstract

Artificial intelligence penetrates into all spheres of the system-informational culture ergonomics. Robotics universality can be accomplished in the paradigm of cooperative approach and artificial intelligence usage. Intellectual robots can make decisions autonomously. Distributive control in the cooperative system of robots allows to find optimal solution of the needed scheduling problem. The relational game theoretical approach is to be used for robots' simulation. Instead of the traditional games problem formulation, relational form has to be applied. This reduces the dimension of the tasks solved. Cooperation is based on messaging through communications network. Its choice becomes the essential part of players' decisions making based on the application of the game principles of equilibrium and effectiveness.

Keywords: multiagent system, intelligent player, relational game, coalition, communications network, scheduling problem, category of binary relations; preferences, precedence, capabilities, opportunities relations

Volume 11 Issue 1 - 2025

Vasilyev NS
Department of Fundamental Sciences, Bauman Moscow State Technical University, Russia

Correspondence: Vasilyev NS, Department of Fundamental Sciences, Bauman Moscow State Technical University, Russia

Received: April 14, 2025 | **Published:** May 1, 2025

Introduction

In the ergonomics of the up-to-date system-informational culture there is a trend of artificial intelligence increasing usage.[1] The trend is also observed in robotics. A new technology of robots' team self-organization is expected to appear. In the article, robots' cooperation is simulated by means of multiagent systems (MAS) study. Intellectual agents are quite capable to process incoming information and make independent decisions. The game theoretical approach can be applied to cooperative robotics development.

The traditional game problem statement will have to be abandoned.[2] Firstly, the choice of players' payment functions in applications raises many questions. Secondly, the number of pairwise different game situations increases exponentially with the number of players. In my opinion, the game must be stated in the form of relations.[3,4] Situations of the game are different game completion options. On their set agents' interests can be represented with the help of preferences relations. Players' capabilities can be also expressed in comparative form. The approach significantly widens the sphere of games applications[5] and diminishes the dimension of the solved problem.

As for robots' cooperation, their aim is to provide a set of tasks which is also preordered by means of a precedence relation. The agents have to compete to choice the most suitable tasks for them. In order to do it, they lean on their preferences relations and consider heterogeneous capabilities of their partners. Decision making uncertainty forces them to cooperate by means of messaging. Communications network choice becomes the essential part of the players' cooperative behavior. They can apply acceptable strategies depending on their awareness provided by the exchange of information.[2–4] The players have to find the optimal tasks scheduling[6] which is to be stable. It is required to find solution of the game based on the equilibrium and effectiveness principles.[2] In the relational game it can be achieved with the help of a polynomial algorithm.

Problem formulation

Category of binary relations[7] suits to the aims of MAS simulation in the most general terms. Allow robots' preferences relations $\rho_i \in R = \{\rho_i, i \in I\}$ be given on the set A of all tasks to be provided. The tasks are to be completed according to the ordering (A, τ) according to the given precedence relation τ. The smallest elements of the preordered set (A, ρ_i) cannot be at all accomplished by robot $i \in I$. Every task is to be fulfilled only by one of the robots. Capabilities of the agents are compared with the help of the given relationship $\varphi \subset \mathrm{A} \times I \times I$. Property $(A_j, l, m) \in \varphi; l, m \in I$, means that robot m makes the task $A_j \in \mathrm{A}$ better than robot l.

The precedence relation defines dynamics of the game. The latter can be divided in series of static subgames where executed tasks do not connected by relation τ.[4] In each of them, situations are partial schedules. By their strategies, players can influence the implementation of certain scheduling scenarios $S_k \in S$. The possibility is also expressed in the comparative form of the players opportunities relationship $OP \in REL(I, I, S)$. If the property $(S_k, l, m) \in OP; l, m \in I$, takes place, player m has more influence on the schedule S_k realization than robot l. In all static subgames, players use messaging to form coalitions. Their aim is to come, if possible, to the optimal partial scenario $S_{k^*(i)}, i \in I$. It means, the task from the scenario $A_{j^*(i)} \in MAX\rho_i$ may be executed by robot $i \in I$. Coalitions are to be created by agents themselves. For the purpose, intelligent robots are able to use the set of relations R, OP to find effective hierarchical and parallel coalitions.[3,4] In this way, optimal communications network emerges which makes players' moves preordered. Due to it, every coalition C picks out the set of tasks $\mathrm{A}_C \subset \mathrm{A}$ to be provided. The tasks $A_j \in \mathrm{A}_C$ can be reassigned among partners $l \in C$ to achieve Pareto optimal scheduling.[8] For the purpose, relationship $\varphi \subset \mathrm{A} \times I \times I$ is used.

Cooperative scheduling

Distributed control in the system is coordinated by messaging. Robots inform each other about tasks they chose to provide. As coalitions are formed, any static subgames is to be reduced. Coalitions have their own strategies intended for the scheduling optimization leaning on their preferences relations ρ^C termed *characteristic* ones.[3] Every coalition is regarded on as a player in the reduced game. The relations ρ^C are compositions of initial robots' preferences relations built with the help of the following monoidal operations. They are relations disjunctive sum $\rho_1 \coprod \rho_2$ and superposition $\rho_1 \circ \rho_2$ correspondingly.[7]

Example 1 Parallel $C_p = C_1 \cup C_2$ and hierarchical $C_h = C_1 \to C_2$ coalitions, made up of coalitions C_1, C_2 previously formed, have the following characteristic relations:[3]

$$\rho^{C_p} = \rho_1 \coprod \rho_2, \rho^{C_h} = \rho_1 \circ \rho_2$$

This is how all coalitions are built.

Applying relational Bellman's method to the scale (A, τ), dynamic relationships $\tilde{\rho}_i(t), i \in I,$ are built [4]. The equilibrium scheduling is found as solution of the problem $\tilde{\rho}^g \to MAX$. Here, the game resulting relation $\tilde{\rho}^g$ is characteristic relation of the whole dynamic game.[4]

Conclusions

In the system-informational culture artificial intelligence develops human tools. Intellectual robots' cooperation allows solving effectively relational scheduling problem. Future technology consists of relational approach application. Intellectual robots' cooperation engenders a distributive scheduling method through the communications network chosen by them. The algorithm has polynomial complexity. This is a general trend in the development of intellectual multiagent systems.

Acknowledgement

No financial interest exists.

Conflict of interest

No conflict of interest exists.

References

1. Gromyko VI, Vasilyev NS. From automatization to neurophenomenology of artificial intelligence in robotics. *Int Rob Auto J*. 2018;4(1):1–2.
2. Germeyer YB. Games with not opposite interests: Moscow; 1976.
3. Vasilyev NS. Multiplayers' games compositional structure in the monoidal category of binary relations. *J Informatics and applications*. 2023;17(2):18–26.
4. Vasilyev NS. On functorial representation of optimized dynamic multiagent systems. *J Informatics and applications*. 2024;18():2–8.
5. Dixit AK, Skeath S, H Reiley. Games of strategy: New York, London: WW Norton & Comp; 2017.
6. Bellman R, Esogbue AO, Nabeshima I. Mathematical aspects of scheduling and applications: modern applied mathematics and computer science. 1st ed, In: EY Rodin, Editor, Pergamon Press; 2024.
7. Mac Lane S. Categories for the working mathematician. Springer, 2nd ed, 1998.
8. Podinovsky VV, Nogin VD. Pareto optimal solutions of multicriteria problems. Moscow; 2007.

Citation: Vasilyev NS. Cooperative robotics in system-informational culture ergonomics. *Int Rob Auto J*. 2025;11(1):25–26. DOI: 10.15406/iratj.2025.11.00296