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Inference algorithm for teams of robots using local interaction

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Abstract

One of the possible approaches to the technical implementation of logical inference in robot groups is considered in paper. The problem is that the usual implementations of the inference mechanism, for example, which are used in expert systems, are difficult to implement to robots that work in a team. It is due to the fragmented knowledge of each robot about the environment where they perform the tasks assigned, the need to exchange data during the inference and monitor this process, etc. In addition, the presence of an inference subsystem may be necessary for emergence of emergent properties in a group of robots. The output subsystem can be used to solve a variety of tasks, for example, choosing the most preferred strategy for the whole collective, building a general picture of the world, planning, etc. In this regard, the paper presents some mechanisms that allow the inference in the logic of predicates of the first order for a team of robots whose interaction with each other is exclusively local in nature. The inference procedure is carried out in the team of robots, which form a special structure, called a static swarm.

Keywords: inference, robot swarm, static swarm, local interaction

1 Introduction

The implementation of inference in groups of robots using local interaction is considered in this paper. The logical output subsystem is one of the robot subsystems, which presence can allow the collective of such robots to exhibit emergent properties, i.e. solve qualitatively more complex tasks (Karpov, 2013). In the simplest case, a robot with such subsystem can choose from the list of possible actions the most preferable from the point of view of the current situation, the goals it faces, and so on. (Stuart, 2006). More complex tasks are solved with its help: planning, building a picture of the world, etc. (Bratko, 1990).

If you don't consider the robotic aspect, then inference is widely used, for example, in expert systems. In addition, there is also a convenient tool that allows you to solve both similar problems and a number of others, implemented in the Prolog language (Bratko, 1990). However, using such mechanisms in real technical devices has its own specifics, especially for robot teams, where the organization of the inference subsystem is highly dependent on the organization of interaction between robots. For example, in (Karpov, 2013) is shown that the implementation of the inference

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on Prolog leads to a situation where all the resources of the team are aimed at inference and proposed using of linear inference based on the produce.

Indeed, if we consider the case with a single robot, then it is enough just to correctly interpret the sensor data and to make an inference using the search mechanism with a return and unification. A suitable example of a robotic system can be the robot Shakey (Fikes, 1971), where the STRIPS planner was implemented. Another example, described in (Jonsson, 2000), is a scheduler for a spacecraft.

In the case of a team of robots using the Prolog, the following problems can arise:

- The starting problem. There must be a special robot in the group that initiates the inference procedure. If you allow the possibility of initiating an inference to all members of the team, this can lead to large amounts of transmitted data between robots. This will result in a high load of communication channels and data loss during the exchange process. Thus, a mechanism is needed that makes it possible to single out such a robot from the whole team.
- Local character of interaction in a group of robots. The essential limitation is that each robot can exchange data only with a limited number of neighbor robots. This limitation is necessary, firstly, in connection with the high resource-consuming nature of the approach that provides the "all-to-all" connection. Secondly, if we consider biological systems as an object of imitation of collective robotics (Karpov, 2016), it becomes obvious that the connection "all-to-all" is impossible. Consequencely, channels implementing this type of communication will be low-speed, which will interfere with intensive data exchange between robots. This is another argument against initiating the withdrawal of all the robots of the team.
- Fragmentary knowledge base, i.e. each robot of the team most likely doesn't have all knowledge of the area of habitation. Moreover, the individual knowledge of one robot may conflict with the knowledge of another (Vorobiev, 2015), which also introduces certain features in inference . Besides, it is impossible to consider the collective of robots and as a distributed knowledge base. There is no robot, which has a structure that would describe which robots store this or that information (Karpov, 2013). Thus, it is problematic to use address requests to specific robots carrying the necessary data.

In this connection, in order for the inference to possess the completeness property in such a team of robots, it is necessary to search for subgoals in all elements of the collective, i.e. sending requests from the robot that initiates the logical inference to everyone else, using retransmission requests. It is important to remember the received requests within the output of one goal in order to avoid the situation of duplication, when the same multiple request is processed more than once.

- Since the search for subgoals must be performed in the whole team, the problem of processing the response arises. It is, the time required for an answer to reach the robot realizing the inference is inversely proportional to the number of retransmissions of this response. For example, a response that requires three retransmissions will arrive after a response that requires one retransmission. Thus, the order of their location in the addressee's database depends on the time of their arrival. In this connection, the situation described in (Stuart, 2006) in the ninth chapter or in (Bratko, 1990) may arise, where a different ranking order of the rules in the knowledge base leads to different output results. In certain situations this process can be infinite.
- Stopping problem. The procedure of inference shouldn’t end if the robot initiating it could not find in its database facts or rules comparable with the subgoal, since such facts and rules can be in the knowledge bases of other robots.

Thus, we can say that the organization of inference in a team of robots is reduced to the organization of distributed search, which takes into account the aspect of the technical implementation of interaction between robots. In other words, the task is reduced to solving the task of parallelism at the search level (Vagin, 2004).

2 Feasible solution

These problems can be solved as follows: