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DECENTRALIZED MULTIROBOT SYSTEMS

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To expand the capabilities of the robotic system, it is advisable to use a group of robots, rather than a single robot. The article discusses decentralized control strategies for multirobot systems. The article presents the basic principles and functioning algorithms for collective, flock, and swarm control.

Keywords: multirobot systems, decentralized control strategies, collective control, flock control, swarm control.

Multirobot systems expand the capabilities of robotic systems. The operation of multirobot systems can be based on various control algorithms. Depending on this, the following group management strategies are divided: centralized control and decentralized, which is divided into collective, flock, and swarm control [1].

The essence of a decentralized management strategy is that each group robot independently makes decisions about its actions. Decentralized control has much higher reliability than centralized because the failure of one or several robots of the group doesn't entail the termination of the system.

1. Collective control

A collective control strategy implies that robots in a group exchange information about their state and the state of the environment. For this, the channel of interconnection between all robots must be formed, besides, each robot in the group must have sufficient computing resources to process a large amount of information from other robots [2].

Thus, this strategy has significant drawbacks: failure of the communication channel entails the termination of the system; powerful computer technology is needed; the strategy is based on complex functioning algorithms; longer decision-making time for each robot compared to other strategies.

If we talk about the simplicity of implementation and minimization of the necessary computing power, then flock and swarm control better meet these requirements compared to collective control. Let us consider these control strategies in more detail.

2. Flock control

With a decentralized control strategy, each robot in the group independently makes decisions about its actions. In the case of flocking control

(Figure 1), robots make these decisions based only on the purpose and interactions with the environment [1].

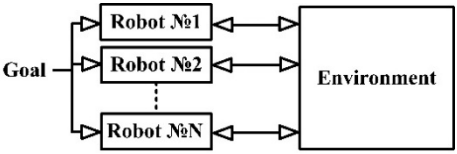

Fig. 1. Flock control strategy

These systems are distinguished by the fact that the robots of the group do not have a common information exchange channel, and therefore cannot coordinate their actions. Thus, robots do not know the behavior model of other robots, their number, and characteristics. All their actions are formed solely based on the goal, information about the behavior model of this robot, i.e. the possibilities of transforming one's state, and information about environmental changes. In the event of a reaction from some external forces, this reaction is perceived as a change in the state of the environment.

The task of synthesis of flock control is the formation of algorithms for choosing a strategy for their actions by each robot, which ensures optimal achievement of the group goal, in the absence of direct information about the status and actions of other robots. If a group of robots operates in a dynamic (changing) environment, we cannot pre-select the optimal behavior models for each robot that operates throughout the entire time the system operates and contribute to the achievement of the goal. We need to formulate the robot solutions in the flock at each step or refine them [3].

Thus, summarizing all of the above, the *n*-th robot of the group must constantly make decisions about its actions. Since we have a group of robots (a pack), not a single robot, the *n*-th robot of the group must take into account the behavior of the flock. This is done by obtaining information about the environment, which other robots of the flock to affect (Figure 2).

3. Swarm control

This control strategy is intermediate between collective and flock management. In the case of swarm control, each robot of the group interacts only with some of the robots closest to it. Thus, a robot in a group forms its actions based on information received from nearby robots and information on the environment (Figure 3). Limitations on the radius of interaction with

neighboring robots are imposed based on the range of telecommunication devices or are formed artificially [4].

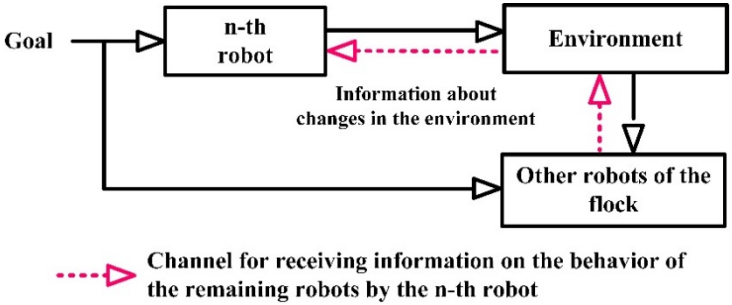

Fig. 2. Flock control strategy

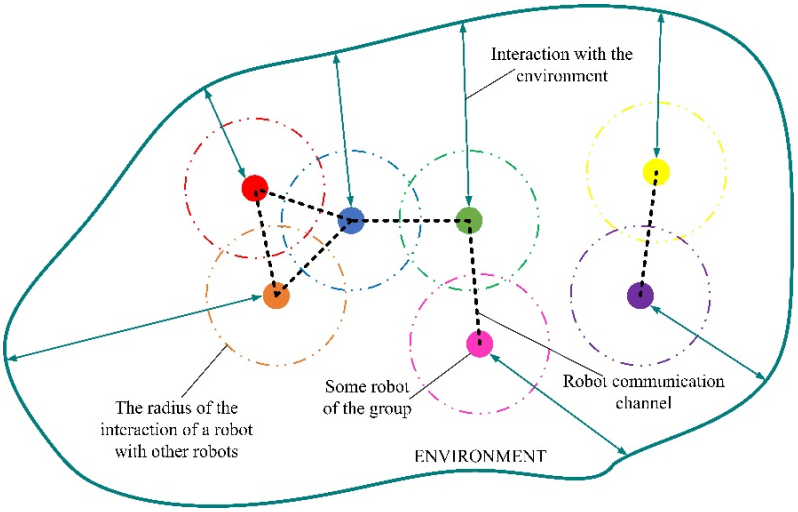

Fig. 3. Swarm control strategy

4. Features of the design of systems using swarm and flock management strategies

For the design of systems using flock or swarm control strategies, it is necessary to take into account their features. We single out the general and individual features for these types of control.

These management strategies integrate the following:

– robots must be autonomous, i.e. able to independently move and interact with the environment without centralized control;
– the need to develop a system with scalability in mind – the ability of the system to adapt to expanding requirements and increasing the volume of tasks;
– redistribution of tasks in the event of failure of one or more robots, which shouldn't affect the integrity of the system;
– these systems consist of a sufficiently large number of objects, which implies the need to use inexpensive robots;
– the need for the individual development of the system for each new task [4].

The flock control strategy has the following features:

– robots of the group should have some environmental impact, i.e. interact with her, as this is the only way to communicate between robots.

Unlike systems based on flock control, a «swarm» should

– have the organization of communication between robots, i.e. the need to equip each object with a communication device.

In conclusion, it should be noted that you need to choose a control strategy based on the characteristics of a particular system, available resources, system requirements, and goals.

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