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INTELLECTUAL CONTROL SYSTEM FOR A GROUP OF MOBILE ROBOTS

Abstract: The object of the study is the intelligent control system of the mobile robot. The problem of intelligent control for a group of mobile robots in an uncertain environment is the difficulty of building an effective control system with a quality system of situation identification and neural networks, which provide sufficiently accurate data for effectively coordinated interaction robots in a group.

The article considers the control system of the mobile robot's behavior using the construction of a sensory map of the mobile robot's movement and its functional model. The structure of the robot group coordinator situation identification system is also built, according to which the robot coordinator can process information coming from the environment, build a map of the area, identify obstacles, plan obstacle traversals based on processed information, and has the ability to communicate with coordinators of other groups and data center for the collaborative work of groups of mobile robots to perform the task effectively. In addition, the article presents the concept of a multilevel intelligent control system for mobile robots, which proposes to build an intelligent control module of three levels, based on the model of thinking and classification of tasks by level of information. The intelligent system can be used in conjunction with a situation identification system to improve the accuracy of interaction between both the mobile robot and the group of mobile robots by including intelligence components in the control system of the robot coordinator group or by obtaining processed data from the Monitoring and Control Center through the group coordinator. The main methods of group intelligent control of mobile works are considered.

Keywords: intelligent control system; mobile robot; neural networks; group control; automation.

Introduction

The robot control system performs many actions to switch modes of operation and services that the robot can perform in a group or independently, which determines its basic functionality. It responds to many input signals in events, situations, commands, and other types, as shown for UAVs in Figure 1. Based on weakly coupled software components used by the intelligent subsystem to determine the transition to optimal mode, respectively, available combinations of input signals. Work behavior is limited by tasks, algorithms, situations, events, factors directly affecting the work or group/subgroup, built-in functionality, state of internal systems, power supply, a priori restrictions, safety conditions, and level of intelligence.

In the future, we will understand the coordinates and order of the robot in a group/subgroup in 3-dimensional space (Cartesian coordinates) relative to other robots and obstacles in the sector of their movement. It is displayed as a 2-dimensional sensor map provided that the object controls and obstacles are at the same height and are assessed by a situation identification system. The touch map is formed dynamically on the route. It is compared with a priori given fragments of the route map of the task, which was stored in the robot's memory before the start, based on which new obstacles or objects on the group route are identified, and new trajectories are predicted for each robot—safety zones relative to each other and in the group.

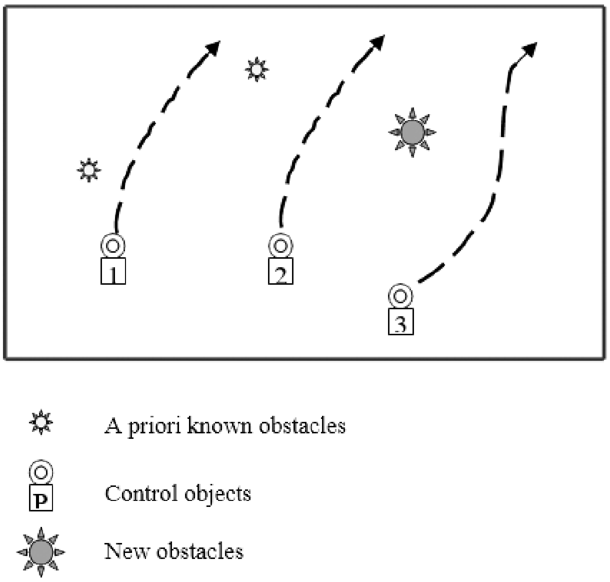

Figure 1. Touch map in the horizontal plane of the trajectory

The model of the sensor map for the horizontal plane of movement of the UAV group under the condition of constant height has the form shown in Fig.1. A sensory map is formed that corresponds to the vertical section for robots of subgroups/groups. Touch map for distance (coordinates of robots in a subgroup or subgroups in a group) their location relative to each other may not be created. Data can be obtained based on the location of the subgroup coordinator, taking into account the limitations of a priori "safety corridors" trajectories in such a system and route map of the task.

However, to increase efficiency in performing complex tasks, it is necessary to consider expanding management capabilities by introducing intelligent components into the robot control system.

Formulation of the problem

The problem of intelligent control for a group of mobile robots in an uncertain environment is the difficulty of building an effective control system with a quality system of situation identification and the use of neural networks, models of which provide sufficiently accurate data for effective coordinated interaction of robots in the group [1, 2].

The article aims to describe the functional model of behavior management of mobile robots, build a situation identification system, and an overview of a multi-purpose neural network model capable of processing various data depending on the amount of information coming from the external group environment.

Functional model of a behavior management system

The behavior of the robot is determined by the sequence of commands of the control system. These sequences are determined based on the intellectual compilation of a set of data and messages of many robot subsystems. The behavior control system has at its input various signals, commands, influencing factors, and messages, to which it responds consolidated to their possible combinations, using an intelligent component that calculates optimal modes of operation or adapts robot systems, taking into account the actual situation of moving it in a group/subgroup. The group of input signals of the robot behavior management system will include the following: events, situations, messages of other systems and components, signals of sensors, influencing factors, security systems, coordination team, and the Monitoring and Control Center (MCC), as well as task parameters, route, and trajectories on it. The modes of operation of the robot must include all the functions that make up the full range of services that are embedded in it a priori, taking into account their possible combinations and sequence of execution. The list of basic modes can include, for example, mode of preparation for the start (task entry), route movement, movement on the trajectory, obstacle bypass, route map update, “change task”, modes “divergence” and “collection” subgroup, mode “change of purpose”, modes “situation analysis”, “adaptation to the situation” and “identification of the situation”, mode “hang in point”, mode “energy saving”, mode “return to base”, mode “emergency” [3].

Thus, the general structure of the functional model of the behavior management system can be represented as in Fig. 2.

Group/subgroup situation identification system

The identification of situations in the subgroup, in turn, is to determine the coordinates of the robots in the group, which can create a "swarm" of robots following its given configuration and route task. When the situation changes in the form of a mismatch between the positions of the subgroup robots, there is a need for constant monitoring of the situation and the ability to correct the coordinates of individual robots as objects of control through a message from the subgroup coordinator for the robot. It is necessary to consider the possibility of new obstacles appearing on a given a priori route and the need to correct the trajectories of both individual objects and the trajectory of the subgroup as a whole.

Assessment of the situation requires its selection and classification based on appropriate images of situations. Such operations require taking into account the limitations of safety zones (or "safety corridors") and comparison with the route map to identify a new obstacle on the route of the group [4]. It was proposed to pre-split the route map into sectors to limit the number of objects and obstacles to be assessed and to calculate the new trajectories of the monitoring objects during the movement within the sector to speed up the calculation.

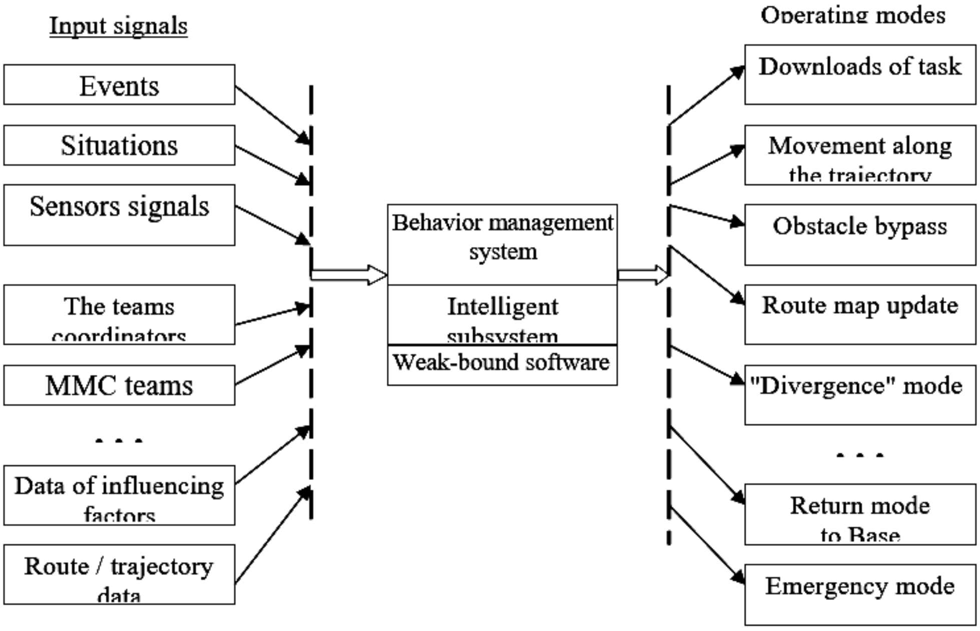

Figure 2. Functional model of robot behavior management system

Situation identification is performed based on the long-range monitoring subsystem, which should be part of the functions of the group/subgroup coordinator, which generates and transmits appropriate messages to other works to correct their trajectories. Based on the above and the information in [5, 6], we can propose a variant of the structure of such a system for identifying situations in the group/subgroup, as part of the behavior control system "swarm" of robots, as shown in Fig. 3. for the robot coordinator.

The robot behavior management system exchanges data and messages with the robot mini-computer, which processes the tasks loaded into the robot and from the CMU, considering the information available in the knowledge base on the behavior patterns of the robot coordinator and robots. This control system also receives after the initial processing signals from sensors of critical and non-critical groups and signals from the navigation system from gyroscopes, accelerometers, and magnetometers. Based on this information, the control system calculates the influencing factors for the "touch map" and the traffic coordination controller for integrated control, taking into account the possible correction of the robot's trajectory based on previous data calculations [7]. The controller generates control signals for the robot coordinator control subsystem.

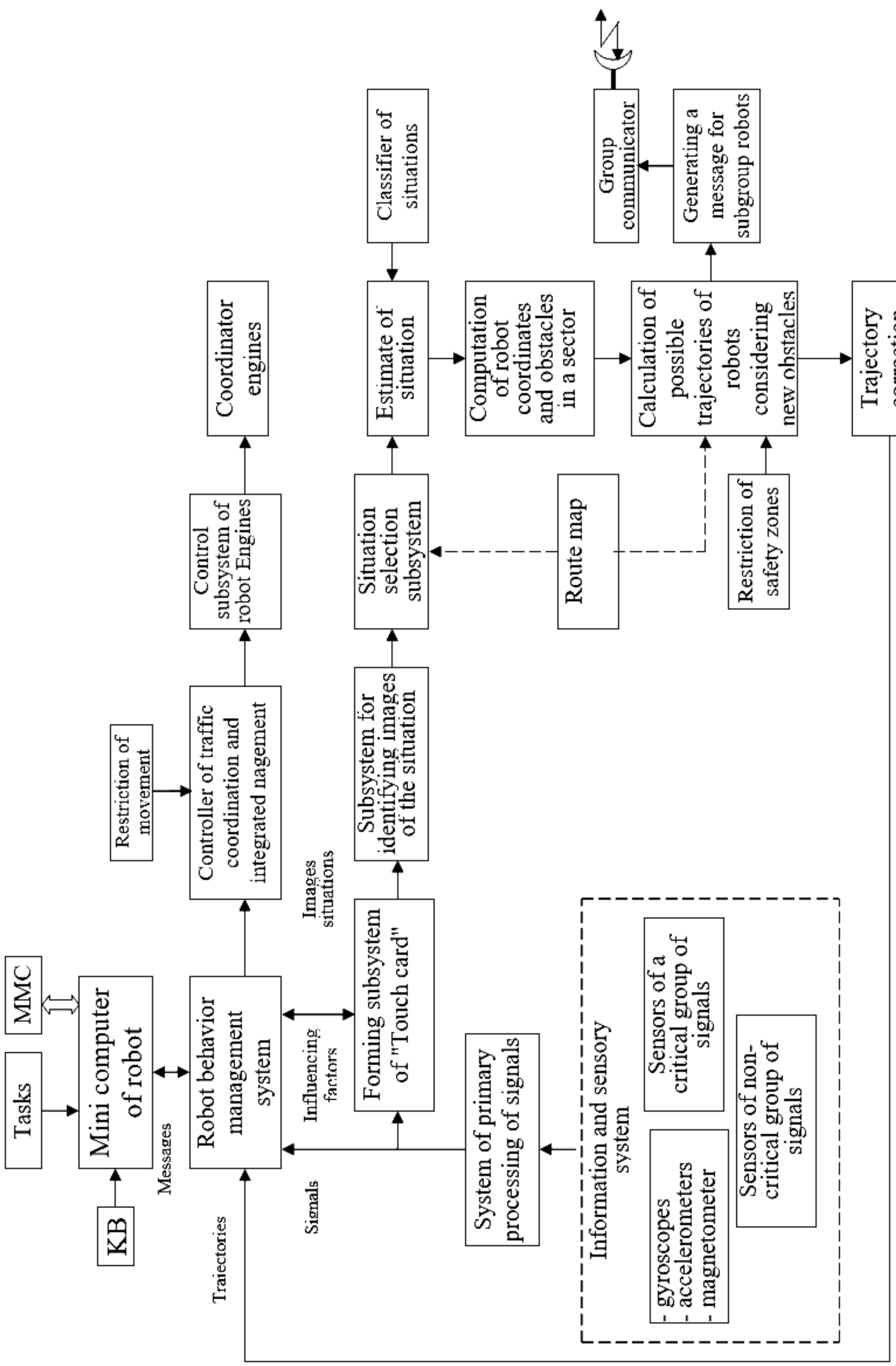

Figure 3. The structure of the system for identifying situations of the coordinator of the "swarm" of robots

The data of the "touch map" in the form of generated images of the situation are entered into the subsystem of identification of images of the situation and then for the stages of their selection and evaluation using the register of situation classifiers according to the location and positioning of robots group/subgroup. The coordinates of each robot and the coordinates of static and dynamic obstacles in a given route sector are constantly calculated. Based on the route map data and preliminary data on robot coordinates and considered obstacles, the possible trajectories of different robots of the group/subgroup are calculated, taking into account certain new potentially dangerous obstacles (coordinates of points or time interval of unwanted "meeting"). for three coordinates - in height horizontally in the direction of movement behind. This data generates messages for group/subgroup robots and is transmitted through the group communicator to subgroup coordinators. The trajectories of robots and group/subgroups as a whole are corrected. Information about the change of trajectories is also transmitted as feedback to the robot behavior management system.

Multilevel intelligent control system for mobile robot

In general, artificial intelligence is used in works to improve the quality of the following tasks:

- processing of sensory information;
- assessment of the external environment and decision-making with logical conclusions; behavior planning;
- management of movements for the implementation of these plans;
- creation of intelligent interfaces for interaction with the humanoperator and other works and the operating equipment

The movement of the work is carried out by controlling the actuators of the executive systems that provide movement [1].

Behavior planning of mobile intelligent robots consists of stages: choice of strategy for the task; forming a sequence of necessary actions; prompt correction of behavior taking into account changes in the environment.

Therefore, the proposed intelligent control system of the mobile robot takes into account the successive stages of its behavior: observation, evaluation, decision making, robot control, prediction of other behavior, self-learning, which involve different levels of implementation: from simple motor reactions to qualitative assessments based on logical conclusions.

When building an intelligent control system for a mobile robot, it is necessary to take as a basis the intelligent control system for dynamic objects presented in Fig.1. The division of the management information system is given based on the proposed in [8] model of thinking and classification of tasks according to the level of information. In managing dynamic objects (which include mobile intelligent work), the final decision is left to decision-makers, such as operators who manage these objects using computing systems used for decision-making and management, including methods of artificial intelligence [9]. At the same time, they have managed automatically at all levels. The operator participates in the adjustment of the robot during his training and in the event of abnormal situations during the operation of the intelligent mobile robot [10].

In the contour of the proposed intelligent robot control system, shown in Fig.4, circulating ups and downs, the system is controlled at its level. Some information is summarized and transmitted to a higher level of assessment of the situation, then as a result of gradual, gradually, from behavioral strategy to the commands on the executive bodies of the robot, the movement is carried out downwards when choosing the options for moving or other any actions of the mobile robot.

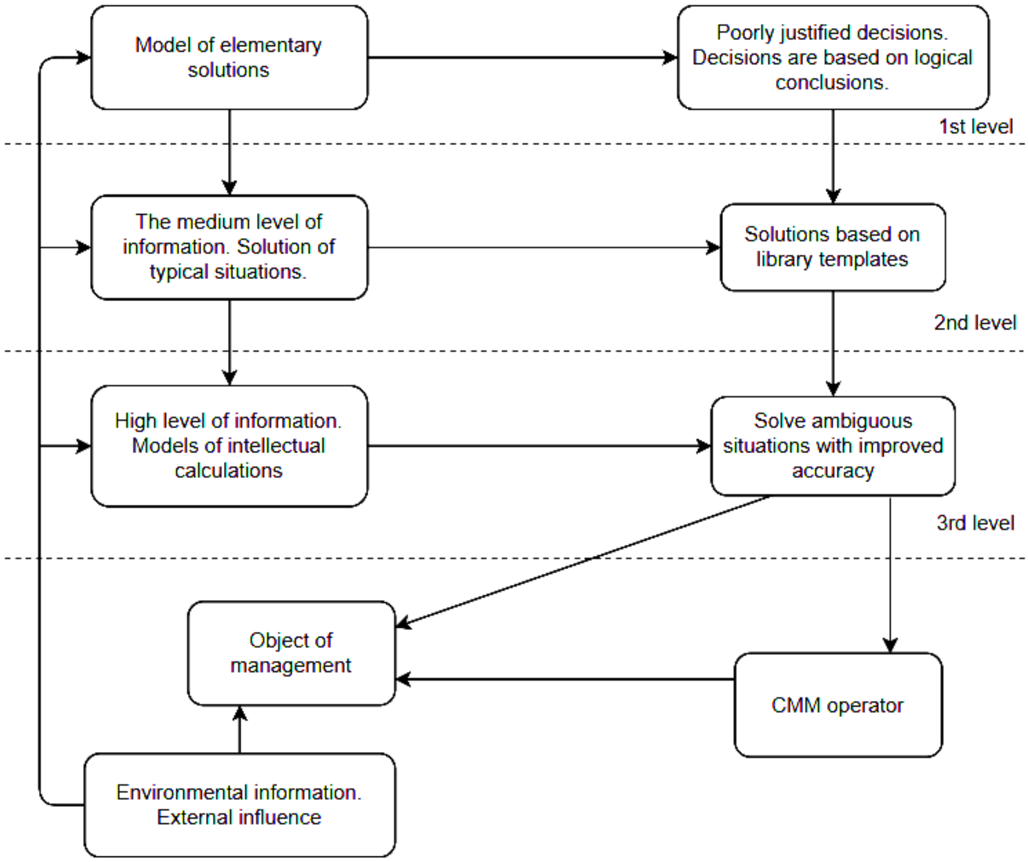

Figure 4. Scheme of the model of a multilevel intelligent control system

At the first level, there is the primary processing of the incoming information. The current management is carried out in case of receipt of the data corresponding to the specified in the task or close to them. Control of mechanisms and movement belonging to the first level of the system is entrusted to the microprocessor system.

At the second level, the intelligent robot control system performs the following functions: technical diagnostics of the robot and its subsystems, quantitative assessment of the robot and the characteristics of the environment, navigation and adjustment of the robot, bypassing or overcoming obstacles.

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At this level, it should provide the most accurate operational assessment of information and, based on it, make decisions on specific actions of the mobile robot. It should include a knowledge base containing the necessary information about the purpose of movement, traffic conditions, other. The system must also draw logical conclusions about the change in the robot's movement with the subsequent transfer of system. Formation of the set influences at the second level is realized differently depending on the purpose and the mobile robot's situation.

The third level of the hierarchy of the intelligent control system of the mobile robot is the level of qualitative assessments. Its presence is necessary due to many subsystems of the mobile robot and subsystems of the intelligent robot control system. It is characterized by a variety of heterogeneous opposite factors that influence the decision to control the robot. To control at this level, you can use various intelligent components - neural network models, genetic algorithms, fuzzy inference algorithms, other models [6].

It should be noted that although the description of the model of a multilevel intelligent mobile robot control system discussed more optimal robot control, the model is designed to solve all the problems facing the intelligent mobile robot control system and its subsystems on the task of coordination in the group. Thus, one of the essential tasks of mobile robot control is to recognize and assess the current situation. Decisions are made depending on the level of certainty, completeness, and accuracy of information about the situation and its assessment: at the first level, decisions are made on specific situations, on the second - on ambiguous explicit situations, on the third - on ambiguous fuzzy situations. The choice of magnitudes and directions of command movements of the mobile robot should be based on the conditions of prevention of collisions with objects (including those that move dynamically) of the environment. In this case, the more uncertain the information about the state of the mobile robot and the external environment, the higher the level of the robot control information system, which solves the problem of robot control.

Conclusion

Based on the results of the article, the functional model of the behavior management system was determined, and the structure of the robot group coordinator situation identification system was built, according to which the robot coordinator can process information coming from the environment, plan obstacle traversals based on processed information. Also, it has the ability to communicate with other coordinators of other groups and is the center of monitoring and management. The scheme of the multilevel intelligent control system model, which can be used together with the situation identification system to improve the accuracy of the interaction of both the mobile robot and the group of mobile robots by including intelligence components in the control system of the robot coordinator group, or by obtaining processed data from the Monitoring and Management Center through the group coordinator.

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