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Model of Control System for Mobile Robots

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Abstract

The paper presents a conceptual model of control system for mobile robots that characterizes functionality of abstraction layers. Each layer describes a set of methods for robot control problems. Presents different computing platforms for these layers. Proposed approach allows simplify further development and maintenance of control system.

Keywords: mobile robot, control system, abstraction layers, computing platforms.

1 Introduction

Some control systems can be construct based on a monolithic approach [1, 3, 5]. In this case, the control system is being developed as a single whole. It is assumed that there will be no further changes. This simplifies the development, but complicate further upgrade. However, most systems are constantly developing. Therefore, the use of monolithic approach is not justified in most cases.

To facilitate the further development of the control system it is better to use a modular approach [2, 4, 6]. In this case, the control system consists of several modules, which communicate with each other. Each module solves his own problem, declaring only the input and output data. When the system is upgraded, are changed only the modules that are responsible for the changed functionality. Other modules remain unchanged.

2 Six-layer model of the control system

Modularity of control system can be organized in different ways [2, 4, 6]. However, the most interesting is the technique, which is taken from on network model OSI [7]. Model of control system for mobile robots characterizes functionality of abstraction layers. Each layer describes a set of methods for robot control problems. Any module of the control system should communicate with modules his layer or with modules per unit above and/or below his layer. Interaction with modules his layer, we call horizontal, and interaction with modules neighboring layer, we will call the vertical. Any module can only perform the function of their layer and is unable to perform the functions of other layer.

Model of control system for mobile robots has six layers. It includes the following layers: microcontroller layer, layer of automaton states, layer of elementary movements, structural modeling layer, layer of scenarios, layer of intelligent control. Consider in detail of each layer and class of problems that it solves.

Table 1. Six-layer model of the control system

	Layer	**Function**
6.	Intelligent control	Solving a macro tasks
5.	Scenarios	Solving a micro tasks
4.	Structural modeling	Safety from self-harm
3.	Elementary movements	User friendly interface
2.	Automaton states	Basic operations
1.	Microcontroller	Control of mechanisms

Microcontroller layer is intended for direct control of mechanisms (servo, power motors, stepper motors, etc.). This layer is typically implemented on industrial microcontroller boards with preinstalled software [8–10]. Microcontroller layer is abstracted from generating of the physical signal. Manufacturers declare a set of commands that are sent through the standard physical interface for control of mechanisms. The set of commands microcontroller isolates from the direct formation of physical signals, but is based on the specifics of the mechanism.

Layer of automaton states is intended for programming of basic operations. This layer abstracts from the specifics of the microcontroller protocols and reflects the robot mechanics. The set of automaton states for each mechanism is based on the generally accepted physical units. For different types of mechanisms are used specific metrics, such as the number of revolutions of the engine power, the degree of rotation servo and others. This layer is convenient from the point of view of the robot, but not from the point of view of the operator.

Layer of elementary movements is intended to provide of the user friendly interface to control mobile robot. The user programs the set of elementary actions

to solve robot task. This layer converts metric of previous layer in the metric, which convenient for the problems faced by the robot. This layer converts metric of previous layer in the metric used for appearing problems faced by the robot.

Structural modeling layer is intended for providing the safety of the robot from self-harm. This layer is widely used when it is impossible or not economically feasible to design a robot so that it could not corrupt themselves in any sequence of action. Functionality of structural modeling is provided by the definition of a set of rules that prevent possible self-damages and solve conflicts of the robot mechanisms. This layer allows programming the robot without constant control of its current state.

Layer of scenarios is intended to create a scenario consisting of specific tasks without the specification of the method of their implementation. The robot receives instructions in the abstract format. In fact, the robot obtains a set of micro tasks to be solved. It autonomously develops a set of basic actions to solve some micro task.

Layer of intelligent control is intended for solving of some macro task. The solution is through its division into micro task. The robot decides when, how and which way to solve the macro task. Ideally, robot doing its job without external control from the moment of inclusion and obtaining of the task. The robot interaction with the user is kept to a minimum as possible.

3 On-Board computer – control computer – supercomputer

The above six-layer model is a logical separation of functionality of the control system of the robot. However, from the point of view of implementation of the control system unimportant role placing each particular layer at a particular computing platform. Naturally, different computing platforms have different computing potential. Moreover, tasks from each layer have different computational requirements. The model allows separating subsystem of the control system for various computing platforms. Every computing platform can implement one or more layers of the model of the control system. For maximum performance of the control system of the mobile robot it is advisable to use three computing platform: on-Board computer, control computer, supercomputer. Consider in detail the each computing platform.

The main goal of the on-Board computer is to ensure the integration of all mechanisms of the mobile robot control system. All peripheral devices are physically connected to the on-Board computer. Microcontroller layer, layer of automaton states and layer of elementary movements placed at the on-Board computer. Higher layers can also be placed on-Board computer, if it has a good computational capability. Choice of the on-Board computer depends on many parameters: size, weight, battery life, and performance. These parameters follow from the requirements to the mobile robot and from the list of tasks to be solved by the mobile robot.

The control computer is connected to the on-Board computer through a wireless network. The control computer is the main element for the interaction of the control system with the user. In particular, the user can modify the software, give the task to the robot or supervise of its activities. Control computer does not need to be mobile. Therefore, it has not limited by power requirement, weight and size. This allows the use of high-performance desktop computer as a control computer. This computing platform provides significant performance gains for the control system of the mobile robot. List of layers for the control computer are defined naturally. It depends on the task list of the mobile robot.

The solving of tasks on the layer of scenarios and the layer of intelligent control are requires extensive modeling. It needs more computing power. Supercomputer is the most powerful computing platform in this model. This platform is built on cluster technology that uses a large number of computers. The main task of the supercomputer to perform calculations that cannot be produced in a reasonable time on the first two computing platforms. The supercomputer is connected to the control computer by wide channel. This allows transfer large data volume, which are needed for modeling.

Conclusion

The proposed conceptual model describes the logical separation of control system for mobile robots. This model does not limit the list of software and hardware that used in the development of mobile robots. Therefore, it may be selected the most convenient framework [2, 4, 6]. Proposed logical separation of robot subsystems allows simplify further development and maintenance of control system. The article also discusses various computing platforms, which allow to solve a wide range of tasks. The proposed logical model allows efficient use of available computing platforms.

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