MARVIN: Mobile Autonomous Robot for research and education

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Abstract

In the article the mobile robot and program providing for researches in a robotics is presented. In the future this system can become the universal tool of the researcher in the field of a robotics. Main ideas of this robot: available components, modular design in everything, a sensor subsystem from sensors of different types, support of popular simulators, programming environment and scientific tools, possibility of home production of the robot.

1.Introduction

Robotics is one of difficult areas of researches, which unites in itself various areas of scientific knowledge. A key problem of any science is the problem of the high-quality and convenient tool for carrying out researches.

Robots for education and researches are one of the most active areas of development today. Practically each research laboratory creates the version of such robot ([1], [2], [3], [4]). It is conditioned by necessity of availability of tool for successful researches or training for robotics. In the process of creation of the robot the researcher is guided by the scientific tasks and methods, therefore creation of the universal robot is rather actual task. In this article the mobile robot, which was created as the universal tool for researches in robotics and education, is considered.

2.Goals

Why are researches on the real robot so important? Science problems share certain real-world characteristics. Unlike textbook problems, there may be no single right answer. Moreover, the world rather than a researcher decides whether an engineering design or a scientific hypothesis are correct. One can almost never ignore resource limitations of time, money, and materials. Finally, real world devices never follow the ideal models. For example, a program that assumes that sensors always deliver exact and valid values and that motors always deliver the commanded speed and torque will be helpless in the face of noise, spurious inputs, unreliable outputs, or breakdowns. Researchers lacking hands-on experience significantly underestimate the importance of these real world issues.

Our purpose in this work has been development of a universal robotics complex for the researches, consisting of the mobile robot and the software for modeling and scientific calculations. Such "robocomplex" will allow carrying out difficult researches not only in the virtual world, but also in the real world.

3. Previous works

The idea of the robot for researches was perfectly considered in works [5], [6], [7]. The key features of such robots are: low cost, modularity, simplicity of programming, multi-functionality. Each of authors tried to find balance between these qualities. So some interesting ideas for such robot are given in work [8], however there is an essential shortcoming. This robot is intended for rescue operations, therefore his mechanic is rather difficult and it is unfit as universal decision for researches and education. In work [9] authors suggest to use mobile robots for researches in adaptive behavior and neurobiology, therefore they chose as a platform the ready project on the basis of LEGO [10], [11]. The shortcoming of such choice is that LEGO is the much unified platform and it is rather difficult to connect foreign developments to it. The development environment LEGO doesn't give full access to the periphery of the robot and it is very difficult to use it together with various scientific packages.

Robot Pioneer 3DX from AdeptRobotics is one of the most convenient developments in this area [12]. It represents a universal two-wheeled platform with productive PC and a software complex for researches with a set of algorithms. A key demerit of this development is the price and unavailability of

some components that is a problem for small robotics laboratories as BSTU.

The idea to combine the virtual robot with real was offered for the first time in [13]. Player/Stage is one of the most popular simulators. More often together with it the mobile robot Pioneer 3DX is used.

As similar robots are developed for specific objectives or are inaccessible, we developed the mobile robot which was named MARVIN (Mobile Autonomous Robot & Virtual Intelligent ageNt). Its primary task is to become the tool of the researches in robotics.

4. Robot concept

The main requirements to such robot is universality, a modularity and availability of components, and restriction — cost. In the process of creation of the mobile robot for researches it is necessary to find a balance between these opposites.

Platform choice.

In robotics various platforms are used: caterpillar, wheel, walking and others. So, there are two most extensive classes – walking and wheel robots. Certainly the platform choice is influenced first of all by a scientific task, however wheel robots are considered as more universal [6]. Wheel platforms have big practical value because of low cost, simplicity, easy in control.

Structure choice.

"Plug-and-play" modularity is essential to our robotics philosophy, allowing researchers to easily combine these components in an almost endless variety of way.

Choice of software structure.

The most universal decision is possibility to program the board computer of the robot and to execute command on the remote computer.

Structure of sensor system.

Usually each researcher uses a concrete set of sensors for the task. But it is possible to allocate two strategies of sensors' choice. The first strategy consists in a choice of several expensive sensors which give out a big flow of homogeneous data. The second strategy consists in a choice of a large number of various sensors which issue non-uniform information in smaller quantity.

For the universal robot, such as Marvin, is more preferable the second strategy.

5.Structure of mechanics and motors

As a platform for the Marvin robot DFrobot 2WD [14] Arduino's popular two-wheeled platform was chosen (fig. 1).

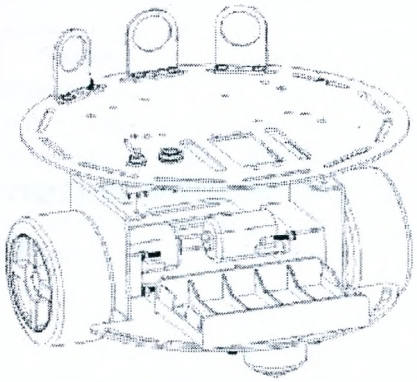

Fig.1 DFrobot 2WD mobile platform

The Arduino 2WD two-wheel - drive robot is a DFRobot original design and widely used as self-developed control panel for the Arduino platform. The platform can be controlled by a wide variety of microcontrollers including the widely popular Arduino. Two differential drives, powered by high-quality high-speed motors and flexible rubber wheels are mounted on a high-strength aluminum body. The motors provide a near zero turning radius. The Arduino 2WD platform was improved for increase of a modularity of the robot. The case of the robot was designed on three modules (fig. 2):

- module of motors;
- module of the onboard computer;
- module of sensors.

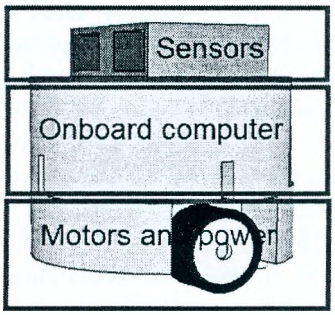

Fig. 2 Modular structure of the robot

Such design of the robot allows changing contents of each compartment independently. The module of the onboard computer is located vertically between the module of motors and sensors. That essentially reduces influence of hindrances from the module of motors on indications of sensors that is very important in scientific researches. Also the middle arrangement of the onboard computer allowed organizing simple and flexible communication of the periphery.

Technical characteristic of mobile robot body:

Sizes of body: 17 x 23 cm
Complete machine Weight: 1,4 kg
Wheel Diameter: 65 mm
Max speed: 61 cm/s

On technical characteristics MARVIN is between classes of small and medium robots that increases its universality in the solution of various tasks.

The main electronics of the robot consists of 3 modules: onboard computer, drivers of motor, power subsystem.

6.Onboard Computer and electronics

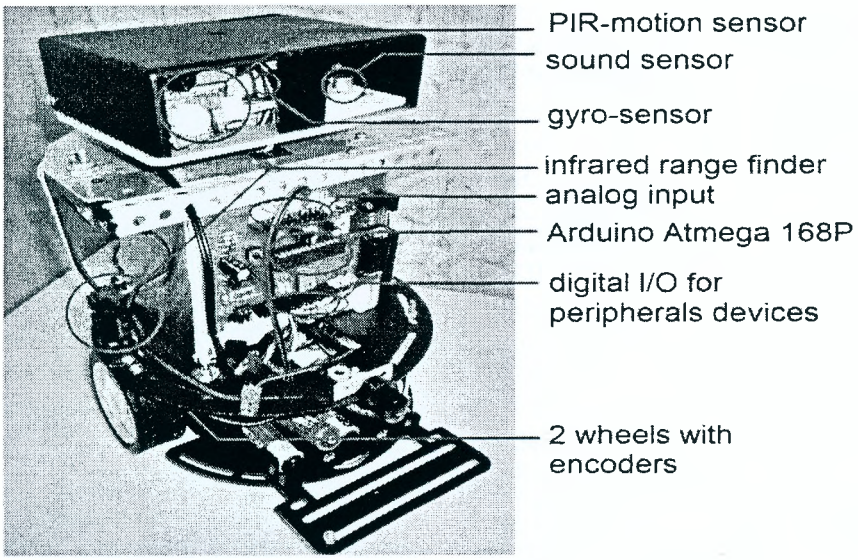

Fig. 3 Placement of sensors and onboard computer

As the board computer the Arduino [15] controler is used. It operates all peripherals devices of the mobile robot. The Arduino platform has a large user base which provides a vast amount of resources and sample programs on the internet. It allows to apply for the solution of tasks the technical means from various areas. The author made Arduino board computer by himself.

In the robot we used motor drivers which were developed and made in robotics laboratory of BSTU. They specially have the small sizes and are equipped. with an optical outcome to reduce influence of hindrances of motors on robot electronics.

The power subsystem of MARVIN was also developed in robotics laboratory of BSTU. It consists of two contours. The first contour - a power of motors. The second contour - a power of onboard electronics. Such strategy is also directed on reduction of hindrances in sensor subsystem.

For communication between the onboard computer and external devices it is possible to use wireless modules Bluetooth, Wi-fi or to connect to it on RS-232.

Arduino is used as the onboard computer for management of the robot periphery (fig. 5).

Big productivity is necessary for the solution of scientific tasks. The wireless communication allows to carry out difficult algorithms on the remote computer or the smartphone. The design of the robot allows to place the smartphone directly on the robot.

7.Sensors

The sensor subsystem in mobile robots is one of the most important parts. Quality of robot decisions depends on quantity of received information. It is known that sensor systems of the people and animals are superfluous.

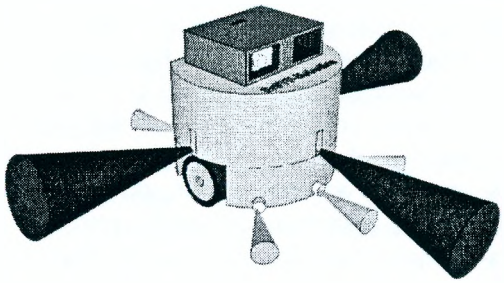

Fig. 4 Areas of collisions detection and obstacles

It allows them to estimate outward things from the various sides. The mobile robot MARVIN is equipped with various types of sensors: three infrared range finders, motion sensor, sound sensor, gyroscope, sensor of vibrations, temperature sensor, odometers, 7 bumper. The scheme of sensor placement is provided on fig. 3.

The sensor subsystem also is modular. It consists of two types of sensors:

- sensors of perceptions around world;
- sensors of robots internal state.

The majority of sensors is placed in the above module for reduction of hindrances from the engines, however some specialized sensors are placed everywhere (fig. 4).

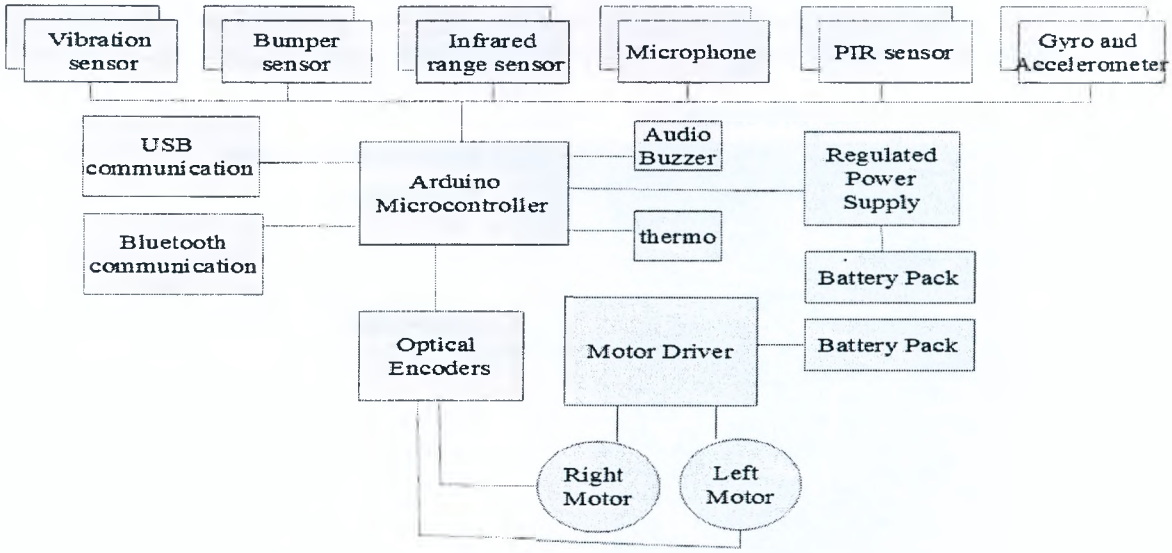

Fig. 5 robot MARVIN functional diagram

The main idea of sensor subsystem consists in use of a large number simple and various sensors. It allows to receive superfluous quantity of different types of information about outward things and on the basis of it to make decisions. Expensive laser cameras and large-format cameras give a lot of information of the same type. The sensor subsystem MARVIN is developed for receiving different types of information.

8.Programming

The Arduino platform allows programming easily the robot through USB, and the program saves after robot switching off. However often Arduino hasn't enough productivity and for carrying out experiments with the mobile robot it is convenient to have wireless access to it. That will give the opportunity to realize the main algorithms on PC, and to transfer to the robot only operating command. For realization of such approach the Firmata project for the Arduino platform was chosen.

This software allows to realize remote access to the majority of possibilities of Arduino through a communication channel. The researcher carries out the algorithms on PC, and the robot only receives commands and sends results of running. The most popular modeling environments of Player/Stage, Webots, ROS support such operating mode. At present there are two models (fig. 6) of the robot for system Player/Stage and Webots. Development of the standard driver for this system is now carried out.

The second approach to carrying out researches with MARVIN is use of a mathematical package - Matlab. For Arduino [16] was developed special firmware for communication with the matlab environment. MARVIN supports this protocol and thus provides to the researcher access to all matlab tools. At present the firmware is adapted for neural network processing of sensors data. In the future it is planned to provide interaction of Matlab tools with other periphery of the robot.

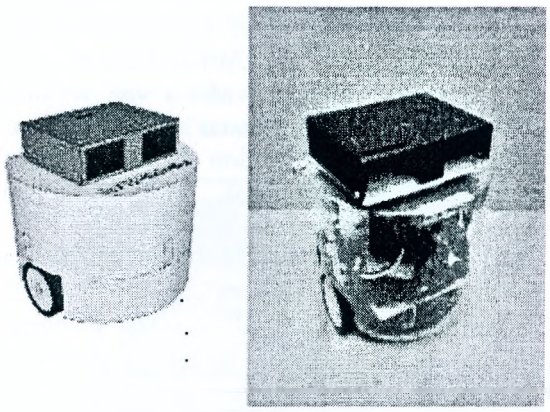

Fig. 6 Mobile autonomous robot and its 3D model

The third way is placement on the robot of the smartphone and management of the robot by means of Androino [17] library. By means of this library it is possible to connect Android software with Arduino. It provides access to the researcher to hardware possibilities of smartphones during standard audio cables. Modern smartphones have the high efficiency, the built-in sets of sensors, the multitask Android operating system, the small sizes. These factors allow to expand robot possibilities essentially. Popularity of the Android platform involves developers in creation of various useful applications which can be used also in a robotics.

Key ideas of the software for the robot are:

1. Use of popular scientific tools,
2. Logging of data,
3. Support of various methods of carrying out experiments.

The offered three ways of researches rather fully cover inquiries of the majority of research tasks that corresponds to the chosen concept.

9.Conclusion and further work

In this article the mobile robot MARVIN and the software for it is presented. Key features of the offered system became:

- modular design,
- electronics of own manufacturing from available components and scheme,
- availability of all components in any country,
- support of the main modeling environments and researches,
- sensor subsystem with various types of sensors and their modular arrangement,
- low cost — 200 dollars.

In comparison with analogs the MARVIN robot looks more available to small laboratories of robotics or educational courses, at the same time being the modern tool. The low cost robots proved to be effective. Despite their low cost and some limitations they were able to perform task usually made by much higher cost robots.

In further MARVIN will be used within a robotics course in BrGTU and in research work of PhD-students. Now the software of the robot consists of a set of models and programs that isn't rather convenient. In the future the uniform control system of the robot will be developed.

The robot hardware already now uses a modularity and supports a set of popular devices, however there are many new technologies which can give new possibilities in researches. In the future support of new technologies will be added.

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Bibliography

[1] K-Team Corporation - *Mobile Robotics.* 2012, Available from: http://www.k-team.com.

[2] Festo Didactic GmbH & Co.KG: *Technical Documentation of Robotino*, Denkendorf, 2007.

[3] Mondada, F. and oth. *The e-puck, a Robot Designed for Education in Engineering.* Proceedings of the 9th Conference on Autonomous Robot Systems and Competitions, 2009, pp. 59-65.

[4] Surveyor Corporation. *Surveyor SRV-1 Blackfin Robot*, Available from: http:// www.surveyor.com/

[5] Nourbakhsh I. *Robotics and education in the classroom and in the museum: On the study of robots, and robots for study.* In Proceedings Workshop for Personal Robotics for Education. IEEE ICRA, 2000.

[6] Kumar, D. & Meeden, L. *A robot laboratory for teaching artificial intelligence.* In Proc. of 29th SIGCSE Symposium on Computer Science Education, 1998.

[7] Schilling, K; Roth, H; Rusch, O, "Mobile Mini-Robots for Engineering Education", Global J. of Engng. Educ., Vol 6, No. 1, pp 79-84.

[8] Raymond Sheh. *The Building of Redback.* Presented at the 2005 Rescue Robotics Camp, Istituto Superiore Antincendi, Rome, Italy, October 2005.

[9] Beer, R., Chiel, H., Drushel, R. *Using autonomous robots to teach science and engineering.* Communications of the ACM, June 1999.

[10] LEGO Education. 2012, Available from: http://www.legoeducation.com

[11] Lego Education WeDo. 2011, Available from: http://www.legoeducation.us/eng/product/lego_education_wedo_robotics_construction_set/2096

[12] Intelligent Mobile Robotic Platforms for Service Robots, Research and Rapid Prototyping. 2011, Available from: http://www.mobilerobots.com/Mobile_Robots.aspx

[13] Gerkey, B., Vaughan, R., and Howard, A. The Player/Stage Project: Tools for Multi-Robot and Distributed Sensor Systems. Proceedings of the International Conference on Advanced Robotics, (2003) 317-323

[14] DFrobot 2WD mobile platform. 2012, Available from: www.dfrobot.com.

[15] M. Bianzi. Getting Started with Arduino, 2008, 128.

[16] Arduino Support from MATLAB. Available from: http://www.mathworks.com/academia/arduino-software/arduino-matlab.html

[17] Interfacing android and arduino through an audio connection. Available from: http://androino.blogspot.com/p/project-description.html

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