

Software of Mobile Robot Motion Control System

Mobile robots work under control of RedCore software engine. Software solution has been implemented on 6 built-in computers running Linux operating system. Movement trajectory control has been implemented on the 7-th computer on the basis of signaling processor. It works in the "real-time" mode without any operating system.

Hardware-and-software complex of the management system performs the following functions.

- Module of stereo vision cameras calculates a dense disparity map and filters it to eliminate wrong correspondences.
- Module of visual navigation according to images taken from 2 cameras. This module determines current position and course orientation of robot, analyzing and comparing the current image with data, obtained during the first training drive.
- Computer, calculating local map and possible drive-ways. This module processes data received from stereo vision cameras module, BINS (Block of Inertial Navigation System), and mechanical odometer to generate 3D map of local area, the robot drives along. It analyses video image of underlying terrain, performs its segmentation and classifies it to find optimal movement trajectory.
- Navigation computer calculates the robot's position and associates it with electronic map taking into account all available sources of information. It prepares data for remote operator's interface on tablet PC. This module saves logs of computers comprising management system and regularly tests operation of all electronic systems of the robot.

All the above listed built-in computers are interconnected into Ethernet local area network and can be accessed from the outside via WiFi-router. To program Linux running computers the following software development frameworks and standards are used: **OpenCL, OpenMP, Qt.**

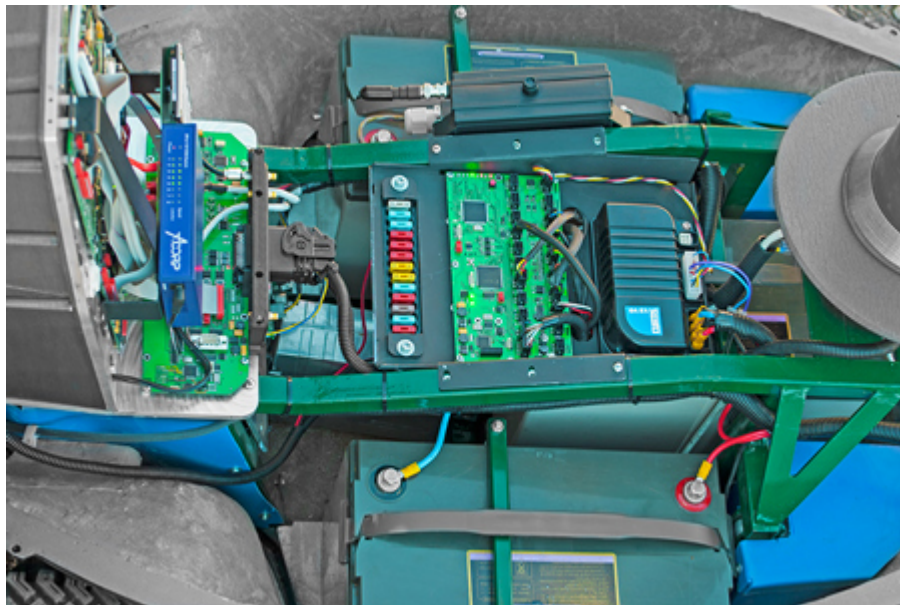
- Module of strapdown inertial navigation system has been built on the basis of micro-mechanical gyroscopes and accelerometers. BINS automatically determines course angle, current angles of roll and pitch of robot's chassis. Embedded software running under control of FreeRTOS resolves the problem of inertial navigation with strict time reference. In background mode it adjusts the drift of



MEMS sensors' zero. Algorithms that process data obtained from acceleration sensors and angular rate sensors use Kalman filtering of the 14-th degree.

- Adaptive motion control module provides synthesis of mobile robot motion trajectory. Combining data from mechanical odometers of wheels and BINS, multi-core computer sets and tracks the motion path, gives commands to low-level controllers, mastering drives motors. It adjusts control actions according to current conditions of wheels adhesion, to possibilities of course maneuvering and to changes of driving speed. It also stops mobile robot in emergency situations.

Basic software configuration is enough for unimpaired operation of mobile robot. However, there is plenty of application peculiarities that need research and optimization of existing software modules as well as creation of new ones.



Robots Programming API

Manufacturer welcomes software refinement performed by regular programmers of dealer-companies and by other partners that have mobile robots at their disposal.

The company issued and supports API of three levels.

- Complex route programming at low-level that is not accessible via operator's interface on tablet PC. Additional devices shall be connected through Ethernet, CAN or RS-485. Data exchange between new device and built-in computers of robot control system shall be made according to agreed protocol.
- Modification of existing software modules in order to meet the needs of their particular application and service conditions. The level of separate Linux processes. Program, implementing new additional features shall run on one of robot's computers and exchange data with other processes with the help of standard Linux mechanisms according to agreed protocols.
- Creation of personal software modules extending robot skills. The level of loaded library. Code, implementing additional features, shall be compiled into Linux library and shall run together with one of the processes on the corresponding robot's computer.