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MULTI-ACCESS CONTROL OF DISTRIBUTED MOBILE ROBOTIC SYSTEMS BASED ON NETWORKING TECHNOLOGIES

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Abstract: *When you create a system for controlling mobile robots, for communication between its elements most often is used (and proved as budgetary) decisions based on the standard networking technologies such as Ethernet. This article discusses exploratory work by the International Laboratory "Sensorika" in this area for computer vision systems of special-purpose robots, control systems of training robots, classes of robots simulators and as well as future directions in this area, including planetary robotics.*
Key words: *sensorics, extreme robotics, video*

1. INTRODUCTION

The main direction of studies at the International Laboratory "Sensorika" is the development and creation of different technological robots and equipment of robotic complexes with sensor systems of different designation. First of all, it is application of ultrasonic sensors and computer vision systems. We have big experience of installation of such sensors onto road-building, hydroficated boring robots, underwater devices and robotic complexes used by the Russian Emergency Situations Ministry. The objective of these studies is the search of solutions for problems of automobile driving, marker recognition, identification of passages, etc. This paper is devoted to the new direction of the development of robotic complexes - multi-access control of mobile robots, based on the networking technologies.

2. COMPUTER VISION FOR SUPERVISOR CONTROL OF MOBILE ROBOTS

At the first stage we consider this problem in a limited version, namely, as the application of networking technologies for providing the group of robots with the controllable computer vision system (Andreev et al., 2009). Usually a computer vision system is the set of technical tools and methods for obtaining, processing, and transmitting images (and data loop), including automatic image analysis and decision making (for example, measurement of geometric and other parameters of objects of the image) and production of control signal supplied to executive mechanisms (for example, in sorting). In a narrow interpretation a computer vision system is the system in which final image analysis and decision making is performed by the man-operator. This is the case most often applied in robotic complexes used by the Russian Emergency Situations Ministry. Several video sensors (for example, video cameras) are installed on robotic complexes with supervisor control and this set of video signals should be transmitted via wireless systems to the monitor for analysis of obtained images by the operator; the operator, in turn, controls the executive mechanisms of this complex via the radio channel.

The main functions of computer vision systems assume the existence of the following components:

1. Video signal sensors (one or several video cameras) installed on board the mobile robot; there can be several such robots.
2. System for collection and primary processing of video data (transformation to the digital form, compression, and formation of Ethernet signal) also installed on board the mobile robot (usually video server).
3. Element of radio channel formation (Wi-Fi reception-transmission); this is the access point with external antenna installed on board each mobile robot.
4. Control panel on which Wi-Fi reception-transmission radio-channel-forming element is installed; for example, it is the access point with external antenna, computer, and monitor (or several monitors) for depicting images from video cameras.
5. Systems of autonomous power supply of electronic blocks.
6. In a number of cases computer is installed on board the mobile robot.

"Satellite" video cameras can be used to simplify the work of robotic complex operator; these cameras are placed in direct neighborhood of the zone in which the mobile robot operates and make it possible for the operator to watch executive mechanisms of the mobile robot; these devices should be autonomous and directly connected with the control panel via Wi-Fi. These satellites can be situated on a simplified mobile chassis (robot-observer).

The main specific feature of our approach to construction of computer vision systems is the transformation of analog video signal from video cameras into the digital form which allows application of all available technologies of signal digital processing and transmission. The most interesting is the Ethernet technology which makes it possible to create computer network including several nodes, a PC on board each mobile robot, a PC at the control panel, Wi-Fi access point, video servers, and so on.

This technology was used at out laboratory to develop computer vision systems installed at the robotic complexes BROKK-110D (Fig. 1a) и BROKK-330 (Fig. 1b).

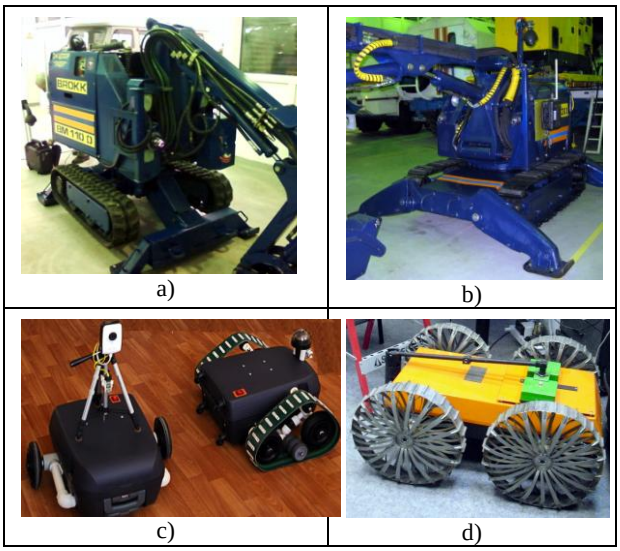

Fig. 1. Software-hardware complex of computer vision systems

Three robots “AMUR” for education, training were implemented in this technology (Fig. 1c) and supplied to the Vladivostok Technical University and Academy of Sciences (Pryanichnikov et al., 2009). At the present time the rover-robot is in the phase of the producing on the base of the chassis for Mars exploration (Fig. 1d). It will have a wide set of sensors and intellectual control.

Promising developments of the laboratory are much wider.

3. MULTI-ACCESS CONTROL

Uniting into one computer network elements of computer vision system of a mobile robot is just the first step. It is interesting to unite computer vision systems of several mobile robots into one computer network which makes it possible to perform salvage operations by means of several robots equipped by different tools. In this case a two-level robotic control system should be constructed. The first level includes operators of robotic complexes. The second level includes the commander who coordinates operator's work. For this purpose the commander should see the whole scene and obtain video information simultaneously from all robotic complexes participating in the operation. Ethernet technologies make it possible to construct such control system. For this purpose it is sufficient to include commander's PC into the computer network and equip the whole network with corresponding software.

The software of the learning and training class of electronic trainers developed at the International Laboratory "Sensorika" for Engineering Technical and Training Robotics Center can be used as the basis for creation of such software. This class (which is still in use) was designated for high quality preparation and regular training of operators of ground robotic tools and remote controlled systems used for elimination of the consequences of emergencies connected with radiation and other factors that forbid the presence of personnel in the zone of operation. This class included 8 PCs and one server united in one computer network. This made 7 workplaces for operator's training, one workplace for the instructor, and one workplace combined with the server for the observer. The developed software provided simultaneous learning and training of 7 operators of mobile robots with one instructor. Such network and software structure can be transferred (with certain revision and update) to the acting complex of several mobile robots, each controlled by individual operator. In this case the instructor serves as the commander.

4. REMOTE CONTROL

Another specific feature of Ethernet technologies is that the commander's PC can be situated practically any distance from the zone of salvage operations (Andreev et al., 2009). It is sufficient to have high speed Internet channel with assigned IP address in the zone of salvage operations and the place of the command post. Such channel makes it possible to unite into one network the commander's PC (or the whole network of the command post) and the network connecting electronic components of robotic complexes participating in the operation. For protection of such Internet channel from unauthorized access it is necessary to use special router capable of creating VPN channel at both ends. Creation of such systems is the promising direction of development in the interests of the Russian Emergency Situations Ministry.

Experts of International Laboratory "Sensorika" united mobile robots situated in the buildings of the Institute of New Educational Technologies and Informatization of the Russian State University for the Humanities, Keldysh Institute of Applied Mathematics of the Russian Academy of Sciences, and in Vladivostok, into one network via VPN channels (Andreev et al., 2009). Corresponding software was developed which provided remote monitoring of the scene and control of these robots according to the created technology of overcoming inhomogeneities and delays in communication channels. Such elements of the system as satellite video cameras become especially important. In this case the operator can observe the scene via the robot eyes (video cameras) and watch the robot movements and execution of commands initiated by the distant operator from the outside.

5. CONCLUSION

It should be noted that the activity in the framework of the concept of construction of computer vision systems with supervisor control proved to be the correct choice. Technically, further activities will be aimed at unification of elemental base of electronic components of mobile robots in order to provide easy transfer of all developments of the laboratory concerning training robots to robots used by the Russian Emergency Situations Ministry and other structures. Certain emphasis should be made on providing the sensor system of robots with the set of different sensors, including ultrasonic and IR vision.

Seemingly, IR vision systems comprise a separate task different from the problems of providing robotic complexes by sensor information. However, including IR vision into robotic system complexes may provide essential effect in application of robots, for example, for perimeter protection. At present there exist a number of problems concerning their application, first of all, the problem of parameter spread of multi-element radiation receivers. The influence of this parameter spread on the video signal is usually called geometric noise. Noticeable developments have been performed in this direction at the Laboratory. It can be stated with certainty that the developed methods for suppressing geometric noise essentially decrease its influence via special algorithms of video signal processing. One of geometric noise filtering methods is presented in this collection of papers.

The creation of the software for integration of different sensors is the main nearest task. In this relation it is assumed that distributed computer network consisting of a low-power PC on board the robot and a high power PC at the control panel makes it possible to transfer some simple algorithms to the onboard computer. The task of analysis of data received from sensors and production of execution algorithms that should be loaded via the radio channel into the onboard PC in the form of small codes is performed by the high power PC at the control panel. In this net the functions of image processing is distributed between the remote computers that give us more stable system of all robots (Andreev et al., 2009 and Katalinic & Kordic, 2002).

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