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INTELLIGENT AND SUPERVISION ALGORITHMS FOR CONTROL OF MOBILE ROBOTS THROUGH INTERNET

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Abstract: *When managing of mobile robot by operator via the Internet in large delays, transient and non-guaranteed delivery of data packets must be applied algorithms compensate for increasing reliability and precision of control. We propose to replace the common sequence of control commands coming from the operator for robot's devices by special supervisor commands with defined features. There is the condition that it will be realized for each of them, regardless of the quality of the control channel. This algorithm was tested and approved by the projects of the International Laboratory "Sensorika": the supervisor control systems via the Internet within the project "AMUR", and the video surveillance via WI-FI at the signal reception edge for special-purpose mobile robots BROKK-110 and BROKK-330.*
Key words: *remote control, internet, mobile robot, intelligent algorithm, supervision algorithm*

1. INTRODUCTION

Development of technology and algorithms for mobile robots control makes it possible to supply robots with a sort of intellect for decision of a number of problems. But, complexity of this problems demands powerful computers, using significant energy resources, installed at the robots. These energy resources could not be supplied, especially within autonomous mode. Besides that, adequacy of making decisions in such systems is sometimes under the question (Pryanichnikov et al., 2009). So, organization of distant mobile robot control, carried out by skilled operator and (or) with participation of computer system, built-in the operating console, could be logically offered.

2. SUPERVISOR CONTROL OF MOBILE ROBOTS

International laboratory "Sensorika" develops systems for supervision control over mobile robots. Training net, uniting, with the help of internet by VPN technology, laboratories, which are situated in buildings of Institute of new education technologies RSUH in Moscow, KIAM Russian Academy of Sciences in Moscow and University (DVGTU) in Vladivostok (Fig.1) (Andreev et al., 2009), is used for implementation of methods of supervisor control at a very large distances. For supervisor control over training robots "Amur" (Fig.2) and for gaining information from different types of sensors software was developed using Turing-complete protocols. This software also allows transferring and displaying several video flows from TV cameras, installed at robots and at separate remote modules, simultaneously (Kirsanov et al., 2009). This hardware-software solutions gave operator possibility to control mobile robot in other laboratories in real-time mode.
But even if the speed of the channel is very high, problems arise restricting this type of supervisor control within salvation of important tasks. During taken experiments for controlling robot in Moscow from Vladivostok (distance between cities -

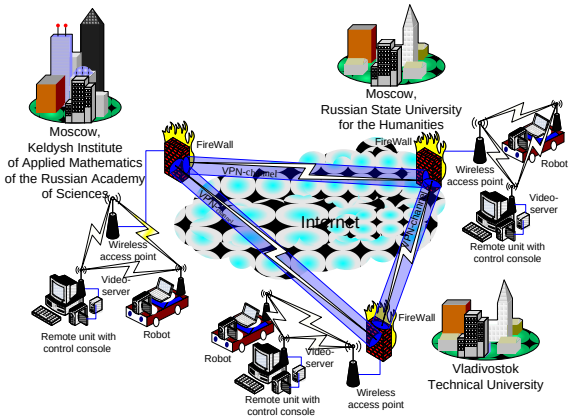

Fig. 1. Education network of Internet-laboratories


Fig. 2. Robots "AMUR" for education

more than 9000km) the operator, directed in conformity with the received videos and data from locator sensors, was not able to follow strictly to given trajectories. Environment information, sent by robot, was received at control desk with different delays, some frame were lost in video-flow. Also in some cases connection between robot and supervise was fully lost during execution of necessary works, for example, within riding into enclosed space. The some situation was during work with special purpose robots BROKK-110D/BROKK-330 (Pist.3) within transferring video-flows from the place of work and commands of PTZ- (pan, tilt, and zoom) control over TV-cameras through Wi-Fi net at the borders of signal. So the supervisor control in real-time mode in conditions of significant delays and within unstable and unguaranteed delivery of data packs could not be usually provided.

3. INTELLIGENT AND SUPERVISION ALGORITHMS FOR CONTROL OF MOBILE ROBOTS THROUGH INTERNET.

We propose to replace the control algorithm for reduce the impact of identified adverse conditions. The common sequence of control commands coming from the operator to robot's

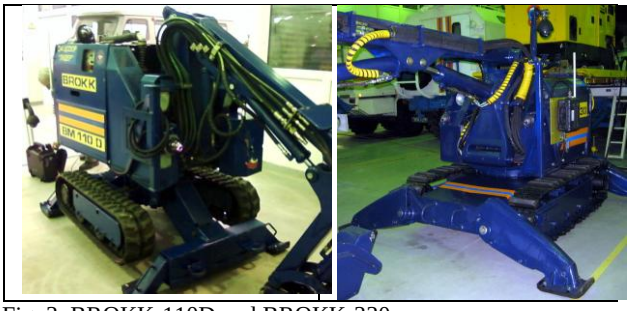

Fig. 3. BROKK-110D and BROKK-330

devices by special supervisor commands with defined features. There is the condition that it will be realized for each of commands, regardless of the quality of the control channel (except the changes of the surrounding space of an experiment or impossibility of performance by any other technical reasons). Thus, an operator at a remote management confident in fulfilling sent supervisory team. However, now he has to anticipate changes in the environment of mobile robot for the execution time supervisory teams and set their characteristics based on them.

Let's illustrate this by the example of mobile robot movement. Suppose in case of fully manual control, the operator controls speed and direction of robot movement with joystick. The operator gets information about robot environment using TV cameras mounted on the robot and other sensors. To move robot from point A to point B along required trajectory he needs to constantly monitor current robot position and perform required movements in the right time. Therefore the operator uses information that comes to the control center more of less time-lagged. In turn, control commands transmitted to the mobile robot also with delays. This leads to inability to perform required task with high accuracy.

Proposed method requires operator to split movement from point A to point B into step-by-step movements, such as "move forward N meters", "turn right (90°)", "rotate by α°" and so on. These incremental movements are first level supervision commands. Set of such commands are finite and predetermined. Possible command parameters and their ranges depend on characteristics of mobile robot. Each of these commands, as said before, will be exactly performed regardless of connection problems. The precision of movement commands doesn't depend on delays during data transfer to control center and delays during transfer of commands themselves. By that in case of correctly planned step sequence it's guaranteed that movement will be performed along requested trajectory.

4. CONCLUSIONS

Further work includes the implementation of this algorithm into a software package to manage the existing mobile robots and the implementation of second level supervisory commands which are more intelligent, e.g. "move to the wall", "move to the charger" and etc. It will require integration into the control system algorithms for autonomous robot behavior by exceeding the threshold or the alarm signal from the external world. For example - the emergency stop movements of mobile robot because of the obstacles, the emergence of which the operator is not predicted.

The experiments have shown the efficiency of this approach for a remote control operator in long delays, as well as volatile and non-guaranteed delivery of data packets. In particular it allows reducing the demands quality of picture from TV cameras available to the operator, thereby reducing the performance requirements of the communication channel between the remote control and mobile robot. Identified sets of first level supervisory control commands and characteristics of possible thresholds in the experiments with different types of robots. Developed algorithms for testing the effectiveness of the approach formulated. Implemented an approach to solving problems remotely control various technological equipment.

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