Multifunction System of Mobile Robotics

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***Abstract*—advertised an international project to create a prototype multi-robotic system. The mobile robot used the concept of multi-level management system, according to which the majority of workload is on-board computer. This will reduce the amount of data transmitted over a wireless link, and increase the efficiency of the development of algorithms for higher-level control. Distinctive features of the project are: the use of original algorithms and firmware, which will develop, maintain and adapt the product for different applications; the use of mechanical components of series production, which will accelerate the certification of the product and will reduce the cost of the product as a whole.**

Keywords—Mobile robot; Multi-level management system; On-board computer; Video processor.

I. INTRODUCTION

Mobile Robotic System – is a machine that can move in space and to perform certain functions due to its specialization. Development and construction of mobile robotic systems are developed in two directions: the first is based on the creation of unique (mechanized) platform, the second - on the use of serial chassis or product as a whole. Examples of robotic systems on dedicated chassis are: multi-functional robots for security services QinetiQ (UK) [1], a mobile robot for fire fighting (Russian) [2]. Most automakers create their own robotic concept car that can drive without a driver on the roads and even "respect the" rules of the road. [3] Typically, such machines, robots are created to test new technologies, and other extra options which could be introduced into its production. For example, in everyday life the machine has already entered the automatic transmission, cruise control, direction, engine start-stop, parking sensors, recognition of road signs, prevention of head-on collision with an obstacle, etc., Which are integral functions of the integrated management system of the mobile robot. However, the domestic mobile robotic systems serial or small batch production, available for mass use in agriculture, utilities and / or law enforcement agencies, yet. This article is announced international project to create a multifunctional mobile robot based on the chassis serial domestic mini-tractors and to introduce the concept of controlling such a robot.

II. ROBOTIC SYSTEMS BASED ON THE CHASSIS SERIAL MINI-TRACTOR

A. Selecting a Template (Heading 2)

The project was initiated in 2013 of LLC "Intelligent Processors" (Minsk) and was included in the program of innovative development of the Republic of Belarus. In 2014 the project has joined the Eurasian National University (Astana), supported by Ministry of Education and Science of the Republic of Kazakhstan. In 2015 the project has entered the organization of Azerbaijan ("Cyber" Ltd. and AzNAN SRI).

Generated product is positioned as a multi-function robotic system for use in environments that pose a risk to the health and life of the driver and staff; For example, in emergency situations - in the liquidation of the threat of explosion, poisoning, fire-fighting; in agriculture - for spraying pesticides and other fields. The specificity of target use of the robotic system will be determined to install special attachments, and appropriate software.

When designing and prototyping the authors sought to emphasize the *simplicity* of design and *reliability* of the use of the robotic system. Its feature is to maximize the use of mechanical components of series production, which will accelerate the certification of the product and reduce the cost of the final product. As one of the variants of the mobile platform used chassis tractors "Belarus-132N" with the petrol engine (HONDA GX390). The power and traction, originally designed for plowing the soil, it is sufficient to ensure that the movement of the trolley up to 500 kg, or clearing blockages with regular attachments. Articulated frame chassis tractors "Belarus-132N" provides exceptional maneuverability of the robot with the smallest turning radius - 2,5 meters, which can be a key factor in the application of complex in a congested urban traffic streets, in the woods, tunnels and even in large rooms. Weight robotic system is about 400 kg with dimensions of 120 × 120 ×

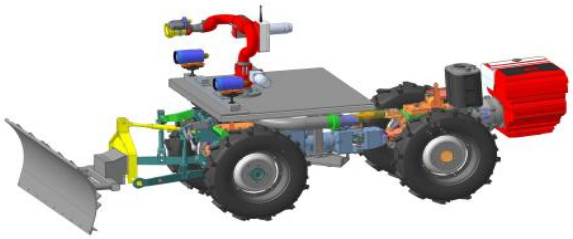

Fig.1. General view of the robotic system on the chassis "Belarus 132N"

180 cm. Physical Specifications allow to transport it in the cargo van with a medium wheelbase or a conventional single-axle trailer. General view of the current prototype robotic system with the original attachments designed for firefighting, is shown in Fig.1.

The complex System, in addition to the serial chassis, includes the following systems and components: a video system for driving; mechatronic motion control system; on-board computer; telecommunication systems with a remote control unit; staff attachments, such as blade; special attachments, such as arm, master stream nozzle for fire fighting. In contrast to the serial product, in robotic systems has changed the basic direction of motion, ie, mobile robot will move "backward-to-front." During this movement the robotic system will be in a secure area, and will not interfere with the video system and the special attachments.

III. CONCEPT OF MOBILE ROBOT CONTROL SYSTEM

In developing the concept of mobile robot is necessary to solve a number of fundamental issues, including the following: to define a strategy (basic methods) positioning and navigation mobile robot; to introduce limitations and detail control modes, particularly semiautomatic and / or automatic; to identify a list of basic algorithms and to link management regimes; implementation of algorithms for distributed computing modules.

A. Positioning the mobile robot in the space

is to obtain information about its coordinates at the current time with respect to a reference system. Positioning is necessary for both the operator and the "most" of the robot to generate commands for further action. Positioning can be carried out as in absolute coordinates (for example, with reference to maps, including digital maps GIS), or with respect to a given point in space (or ground).

The navigation will be understood in the simplest case - the choice of the direction of movement, and in more complex cases - paving the route, the definition of the speed of passage of separate sites, etc. The direction is a horizontal angle measured in a clockwise from 0 to 360 degrees, between the initial direction (usually the north or magnetic pole) and a given line.

For positioning and navigation of mobile robots typically use the following sources of information in various combinations: video; echolocation sensors; radar sensors; various kinds of compasses; accelerometers; Global Positioning System (GPS).

As advertised the project initially used a minimum grade sources of information about the external environment, ie Only video system to ensure the driving. It is a stereo pair of analog cameras with fixed focal length that will algorithmically calculate the approximate distance to objects located in the central part of the field of view. Also, an additional camera, placed on a turntable (in our case - to the fire monitors). Obviously, in this embodimen, positioning may sources of information about a certain given period, for example, the start point of movement, as well as visible landmarks. Thus, the element positioning and navigation (for this project) are:

a) Starting - from the center of the polar coordinate system;

b) Movement is carried out in a straight line at a constant speed to a predetermined point, which can be rotated, with an indication of a reversal of the new guideline;

c) In the course of the movement calculated coordinates distance from the origin of the movement, distance to the landmark, the range to the range;

d) The current relative coordinates and other motion parameters are displayed on the operator's monitor.

For more complex positioning and navigation options, we should use (electronic compass, GPS, tracking system angular-finder, external to the video system of the robot, and others) for additional sources of information. As the project progresses, the mobile robot will be equipped with an optional global positioning systems and inertial navigation.

B. The terms of reference for the development of robotic system were laid following driving modes:

a) Remote control of the (operator) over the air at a distance of 500 meters and a wired (technology) channel - up to 10 meters;

b) Semi-autonomous control of navigation through the on-board video.

Remote control of the operator is carried out by an external PC (laptop) and the control panel. The laptop is designed primarily to display video from cameras, information about positioning and navigation, as well as official information from sensors robotic system. To connect a wireless laptop data reception and transmission Wi-Fi and a remote control, a joystick is installed on a number of radio buttons to select the modes of operation of the remote. The same remote control can be connected directly to the mechatronic system through a wired channel for technological processes; For example, for debugging control algorithms lower level of the loading / unloading robotic system and others.

Options for semi-autonomous control are closely related to the methods and technical means of positioning and navigation:

for example, the operator specifies a reference point (implementing « target acquisition ») and selects the mode of movement, including the speed and transmission gear. For this project, the mobile robot includes the following (generic) versions of motion control.

a) Driving on a landmark that is outside the range of the robot.

b) Movement (return with rotation) from a breakpoint at the starting point of movement.

c) Movement (back reversing « blindly ») from the breakpoints to the starting point.

d) Driving on the program and several benchmarks.

C. Control algorithms

are derived from the methods of positioning, navigation and specific options / motion control modes, ie, the specification functions. On the other hand, the structure and mathematical algorithms developed will largely determine the hardware platform on which is scheduled to be on their implementation, including interfaces and telecommunications facilities.

For example, the present project identified three main levels of computing modules: an external computer (laptop); on-board computer; multi-channel controller actuators (mechatronics) and in addition, a remote control, which can be considered as an additional layer (module). Each module was necessary to define the specification of functions, commands to initialize them, the service (information) data and inter-module interfaces.

When defining the specification of functions for each module a number of technical conditions and design constraints has been taken into consideration which is beyond the scope of the present article. We note that the control system can not be considered robotic systems and / or inappropriate "copy" since, the usual actions of the driver of the tractor acts as a remote control by the operator. So, some manipulation, such as clutch control, gas, brake, steer controls will be carried lower and upper levels. As a result, a comprehensive solution was formed and the following list of functions has been implemented in the respective computing modules.

a) Remote Control: The operator, via the console produces the following commands: "Preparing to start the engine"; "Starting the engine start"; "The choice of parameters of driving: transmission room, four-wheel drive"; "The choice of the direction of movement: forward / backward"; "Start movement"; "Turn left / right"; "Stop"; "Stopping the engine"; "Specifying a guide and commands" Capture "; "The choice of a model variant and semi-autonomous control command" Start ". This list may be adjusted in accordance with the purpose of the complex and attachments.

b) External Computer (Laptop) is designed to display: video data from various cameras (selectively, with a fixed stereo pairs, with the camera placed on the turntable); service information (cursor / window to select the object capture, confirmation signal capture range to the trapped object); position information of the object and information about its current navigation mode, selected movement, as well as for broadcast command / data from the control board to the computer through a wireless system to transmit and receive data.

c) Microcomputer implements algorithmic blocks navigation system and video processor. *The video processor* performs: receiving data from a variety of cameras and temporary storage; video compression with a specific channel and delivery to an external computer; receiving a pointer to the capture of an object, capturing instruction, the « seizure » of the specified object to the issuance of the capture signal to an external computer; determination of distance to an object with the captured output to an external computer; escorting the captured object. *The navigation system* provides: calculation of the data positioning and navigation, and extradition to an external computer; receiving commands from the remote control with the issuance of the controller mechatronics; type storage management software movement, decoding commands from the remote sensors and to initiate these programs.

d) Multi-channel controller actuators: This compute module is a component of the mechatronic robotic system which can be operated from both the command console and commands generated by the navigation system. The number of channels controller is determined by the number of actuators. The main purpose of algorithms and programs of this module is detailing commands top level and their implementation, taking into account the specifics of the mechanical chassis of the mobile robot. For example, a team of top-level "Starting the engine" should check your installation of the transmission into neutral, set the desired level of "pedal" gas, issue a command to start the starter when receiving the signal from the sensor to start, reduce gas, etc. For some top-level commands in the microcontroller algorithms will be implemented. For example, a team of top-level "Start movement" should "squeeze" the clutch, set the transmission of the target shift, "release" grip with the load on the chassis and add gas. Taking into account the comments made, a simplified diagram of the control system, a distributed computing for structural modules is shown in Fig. 2.

The Specialty of the proposed control system is that the algorithms and thus the control program are presented in two levels. Upper level management is implemented by the operator (with remote control) and / or on-board computer. The

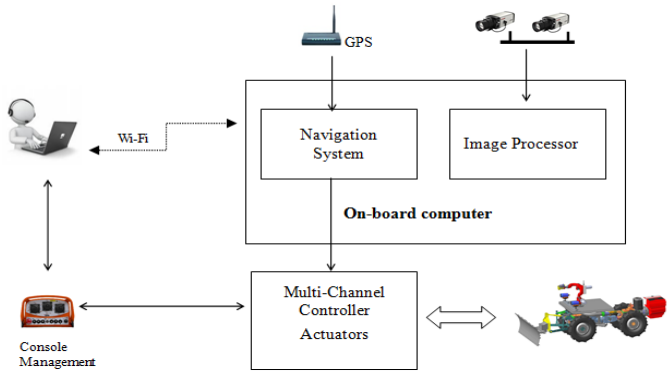

Fig.2. The general scheme of the system of controlling a mobile robot

lower level of programs is implemented to control a Multi-channel Controller Actuators. The lower level is conservative, ie, strictly tied to the structural features of the mechanical chassis actuators (actuators) and the to electronic part of the controller. At the same time the upper level of the developer is available for flexible use of copyright-making both conceptually and technically. In general, this should reduce the time and cost of developing new versions of robotic systems for different groups of authors of the original application.

IV. Conclusion

In this paper, we have announced the project of creating one of the first domestic mobile robotic systems designed for mass production and industrial introduction. One of the main functions of targets is to ensure the affordability of the product. According to the results completed the cost of the mobile robot is expected within 15-40 thousand euros, depending on optional equipment and attachments. This is possible by maximizing the use of domestically produced components (both standard and custom), as well as applying the concept of multilevel governance.

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