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DEVELOPMENT OF THE INTELLIGENT ROBOTIC SYSTEMS

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Abstract

The article presents the results of the creation of robotic complexes (RTC) and the development of the technology of their prototyping, replication. These works are carried out in Keldysh Institute of Applied Mathematics (Russian Academy of Sciences), Volgograd State Technological University and Moscow State Technological University "STANKIN" within the framework of the project "Intelligent Robotronics". Several models of service mobile tracked robots weighing up to 20 kg of the Amur series have been developed, and an underwater walking robot weighting 200 kg. In parallel, a cycle of theoretical and experimental research on the creation of means and methods for the functioning of information-measuring and control interaction of a coalition of underwater floating drones with an uninhabited walking robot moving along the bottom as a base station.

Keywords: Service mobile tracked robots; underwater walking supervisory controlled robot; patrol robot.

1. Introduction

This article is based on the results of the project “Intelligent robotronics”, and dealing with two main problems in robotics – developing the integrating software and fast prototyping. When creating mobile service robots, there is a natural problem of using software of various authors for intellectualization, processing of sensory flows and control. Since the configurations of hardware and software and robot designs are also very diversed, the central task becomes the development of integration software and testing tools for individual packages and devices being combined. The implementation of this project required to make a training system for specialists, using the real tasks of developing service and mobile robotic complexes also used for teaching various specialities: IT technologies, mechatronics, sensors and robotics, industrial automation.
The developed samples of robotic complexes (RTC), within the framework of the Intelligent Robotics project can be delivered to customers fairly quickly, taking into account the modernization necessary for them and with additional sensory equipment. The main problems solved were the creation of technology for the rapid replication of RTC, as well as the creation of reliable, quickly deployable software for the implementation of intelligent supervisory and autonomous control [1], [2], [3]. That is, on our opinion, an interesting experience in the mainstream in robotics.

2. Amur series robots

Mobile autonomous service robot Amur has been developed on the basis of a small transport platform. Amur robot include supervisory control, using radio channels in real time and with autonomous execution of a number of functions. This model is designed for automated transportation of various items and materials in medical and other premises with a dangerous environment for humans, and can also provide inspection and patrolling of such premises.

The intelligent control system ensures safety motion. Control system includes automatic obstacle avoidance under the supervisory control by a remote operator. Operators can control robots in comfortable conditions, without the need to be presented in intensive care wards, infectious sanitary units and isolation wards, in chemically infected areas and other places of restricted access.

The robot design allows medical devices and instruments to be placed on the transport platform using a loader-manipulator with two grips. Amur robot is able to provide technological assistance to both doctors and patients in automatic mode. An autonomous navigation system, using lidar, ultrasonic sensors and rangefinders ensures confident mo of the robot. Navigation system can operate with the presence of unknown obstacles and moving objects, for example, people. A special version of the platform has been developed, which is capable overcoming stairways. There is also a version of robot with partial sealing. It is possible to combine a group of robots into multi-agent hierarchical and heterogeneous complexes.

The developed technology significantly reduces the cost of equipment for facilities with a harmful environment for humans. The Sensorika International Laboratory in Moscow has deployed a framework for the manufacturing of small series of such RTCs.

The main characteristics of the Amur-307 robots:

- total mass of the base platform, less than 25 kg;
- maximum total weight of transported items is 15 kg;
- dimensions of the platform, excluding the manipulator, are no more than 650x600x350mm;
- dimensions of the transported items on the lifting table, are no more, than 300x300x600 mm;
- power consumption of the base platform, is no more, than 75 watts;
- average operating time without recharging the batteries is 2 hours;
- distance between the links of the double parallel manipulator is at least 350 mm;
- speed range is from 0.1 to 2.5 km/h;
- turning radius up from 0 m;
- surmountable slopes / ramps — up to 30 degrees;
- a complex of rangefinder sensors, a wide-angle TV camera;
- information interface Ethernet (1 Gb/s) or wireless Wi-Fi, RC (up to 1 km).

Fig. 1. Amur-307 mobile platform (a) and loader manipulators (b)

3. Underwater robot

An underwater cargo walking robot with high cross-country capability has been developed and manufactured. The scope of application of this transport platform with a walking mover covers the performance of work on the movement of significant loads in extreme conditions on the unprepared bottom surface of the offshore coastal zone, in the surf zone, in the presence of significant currents and surf waves, moving through swampy terrain, as well as with the possibility of going ashore.

Studies have shown, that the choice of a walking type of actuator, in comparison with wheeled and tracked, provided the best performance, when overcoming obstacles on an unprepared bottom surface, as well as the ability to create a significant traction force exceeding its own weight by almost 1.5 - 2 times (unlike wheeled or tracked actuators, where this parameter is less than 0.55).

The complex consists of a walking robot and an operator's control station located on the shore or on a servicing watercraft. The robot and the control station are connected by a cable. The power supply of the robot is carried out via the cable as well, with the transmission of video images and control commands The robot is equipped with the necessary devices (television cameras, ultrasonic sensors, spotlights, manipulators, measuring instruments for various purposes, etc.). The power supply is organized from a powerful batteries included in the control console or from a gasoline generator.

The main characteristics of the underwater RTC with a walking propulsion:
- the total mass of the base platform, not more, than 250 kg;
- the maximum total weight of transported items is up to 200 kg;
- the dimensions of the platform, excluding the manipulator, are not more, than 2000x1000x800 mm;
- the dimensions of the transported items are not more, than 700x700x1000 mm;
- the distance between the links of the double parallel manipulator is up to 600 mm;
- average power consumption of the base platform, no more, than 2000 watts;
- diving depth - up to 90m, can work on shore;
- speed ranges from 0.1 to 6 km/h;
- turning radius from 0 m, surmountable slopes — up to 30-35 degrees;
- the average working time is not limited;
- a complex of rangefinder sensors, a wide-angle TV camera;
- Ethernet information interface (0.1 Gb/s).

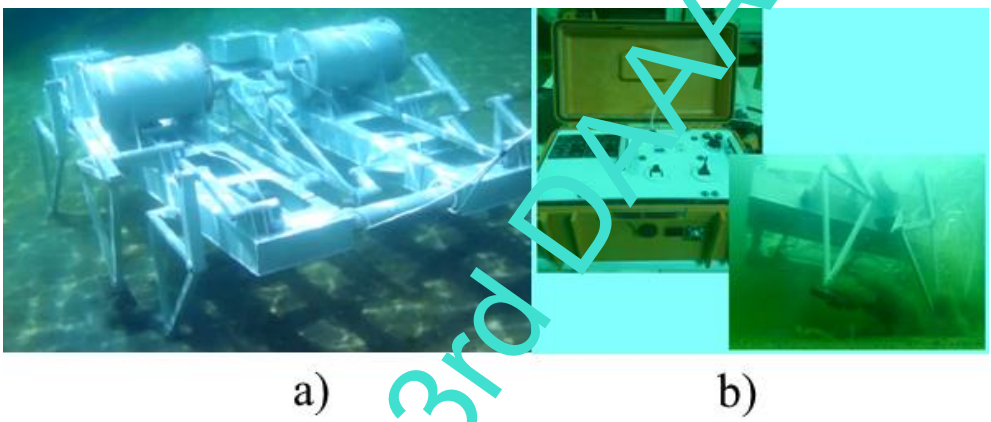

Fig 2. A six-legged underwater vehicle based on a tunable Chebyshev mechanism (a) and its microprocessor control system (b)

4. Comparison with similar robots

Prototypes of walking vehicles and comparison with other other companies. The analysis of the exhibits of the International Military-Technical Forum "Army-2022" [4], materials of the conferences "Extreme Robotics", other sources of scientific and technical information showed an exceptionally high level of development and a versatile approach to solving scientific and technical problems, when creating a variety of developed RTCs. At the same time, a small number of competitors for our developments were found, when solving similar tasks, in particular, when comparing both overall and cost indicators, as well as some important operational characteristics, including load capacity and the ability to overcome obstacles, when moving along an unprepared bottom. The advantages of using a walking propulsion system in underwater systems of a similar purpose, for example, are beyond any competition. For comparison, we will give examples of several of the most interesting developments, but actually related to near classes of RTCs. We present this information from a popular reviews, to show areas of applications.

1. *Amphibian Kalan-M robotic complex*. Fully autonomous (up to 70 km range, up to 2 hours operational time), crawler chassis, satellite controlled, max depth – 5 meters, payload – up to 500 kg. The main disadvantage is low terrain passability and traction characteristics compared to the proposed walking propulsion, an interference-dependent control system, high complexity and cost. Saint Petersburg, Russia [5].
2. *Remote-controlled uninhabited light underwater vehicle "Marlin-350"*. Cable control, two video cameras, propulsion – six propellers, max depth – up to 530 meters, manipulator, robot weight - 60 kg, surface unit weight 85 kg, manual winch 90 kg. The main disadvantage is significantly lower traction characteristics compared to the proposed walking propulsion, high cost. Developer – JSC "TETHYS PRO", Moscow, Russia [6].
3. *Remote-controlled uninhabited underwater vehicle RING PACKET-3000*. Composition: control post (on board or on shore), fixed bottom base station, mobile robot with four propellers. All elements of the complex are connected to each other by cables. The weight of the mobile robot is 5000 kg, the depth of immersion is up to 3000 meters. The

main disadvantage is significantly higher complexity and cost, high weight (incomparable applications). The developer is JSC "Central Design Bureau of Marine Equipment "RUBIN", St. Petersburg, Russia [7].

4. *Remote controlled by cable, walking six-legged robot Crabster CR200*. Possible applications are studying the sea bottom near the coast, taking soil samples. Six legs with 30 mechanical joints. Independence from undercurrents. Dimensions 2.42 m X 2.42 m X 2m, Weight 600 kg, plus a 1000 kg support device, immersion depth – up to 200 meters, cable power from the service vessel. Two video cameras, mechanical capture. Control is operated by four operators. Disadvantages – complexity of construction and maintenance. Developed in the South Korean Institute of Technology and Oceanology KIOST [8].
5. Remote-controlled walking robot SILVER-2. Remote control with the help of an operator on an accompanying vessel via a radio channel with a floating buoy. The dimensions of the robot are 60 x 30 cm, weight 9 kg. The diving depth is up to 200 meters. Operator control from the accompanying vessel via radio channel from a floating buoy, from it via cable with the robot. Shuffles along the bottom on six legs by stepping or jumping, overcomes obstacles with a height of up to 10 cm. Disadvantages – insecurity of the radio control channel, complexity, weak traction. Development of the School of Advanced Studies named after St. Anna, Pisa, Italy [9]

In the papers [10-15] were've published our results in the field of software integration and robotic design.

5. Conclusion

It should be noted, that the main problems of creating mobile robotics are now concentrated around the development of methods for automatic recognition of types of equipment, on specific materials using systems with artificial intelligence, as well as the development of industrial technologies, workplace automation and the improvement of production systems. The complex of research and development carried out by us provides a solution to these problems within the framework of two classes of robotic complexes created by us.

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