Urban search mobile platform modeling in hindered access conditions

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Abstract. The article explores the control system simulation and the design of the experimental model of the rescue robot mobile platform. The functional interface, a structural functional diagram of the mobile platform control unit, and a functional control scheme for the mobile platform of secure robot were modeled. The task of design a mobile platform for urban searching in hindered access conditions is realized through the use of a mechanical basis with a chassis and crawler drive, a warning device, human heat sensors and a microcontroller based on Arduino platforms.

1. Introduction
An important branch of robotics is the development of mobile robots and platforms. The main feature of modern mobile robots is a high autonomy. Most extensive prospects for the use of mobile robots are found in the military intelligence harsh conditions, space exploration, nuclear and chemical pollution, dangerous places to human life [1].

Most robotic rescuers, actually used in practice, are designed and built in the United States and Japan [2-4]. In Russia, projects for the development of rescue robots in most cases do not have proper financing because of the high cost and low profitability.

Despite this, there are already some projects of Russian engineers, for example, the robot prospector Isopod, designed by Russian designer Igor Lobanov. However, this robot remains at the stage of the prototype. Despite all the novelty and prospects of this technological field, such robots are not massively applied. As an exception, one can see only a few sample tests at landfills, exhibitions and scientific conferences. The goal of most of the created rescue robots is an urban rescue after the collapse of buildings, earthquakes and other emergencies.

Such robots as, Tmsuk T-52 Enryu, military rescue robot BEAR, Schaft, are programmed to save people from blockages [5]. They are able to disassemble all sorts of obstacles with their manipulators and other devices, immerse the victim inward in a capsule, or pick up them with the manipulators as hands, and deliver it to rescuers. However, such robots are often remotely controlled [6], or they represent an exoskeleton, which cannot be called an autonomous mobile platform [7-10].

2. Simulation of the rescue robot
Under the scope of the scientific project, an experimental model has been developed - a small autonomous mobile platform in dimensions. Such solution significantly reduce the cost of
development, while existing rescue robots cost varies from tens of thousands to several million dollars [11], which in turn severely limits their application in practice and leaves them only work in the military field.

The second advantage of small size robot rescuers is increasing mobility and maneuverability in the conditions of blockages of buildings and a huge number of obstacles [12-14]. Such robots are able to move along narrow slots, corridors, ventilation shafts and so on. In addition, in large-sized models, the ability to disassemble rubble heavily depends on the equipment and takes too much time. Such robots have quite a large weight from tens of kilograms to several tons, which increases the energy costs for their movement and again reduces their mobility [15]. Therefore, the functions of the developed mobile platform in comparison with its various analogues are limited to: specialized reconnaissance of the terrain in order to detect a person in collapsed buildings, after earthquakes and other similar emergencies, signaling that a living person was found without his subsequent evacuation and without delivery various kinds of objects to them.

A robot as a device consists of:
1. executive systems;
2. information control system;
3. sensory system.

The functional structure of the experimental model of the rescue robot mobile platform components is shown in Figure 1.

![Figure 1. The functional structure of the experimental model of the rescue robot mobile platform components](image-url)

The information-control unit consists of two components:

The central functional part of this unit and the connecting link of all components of the mobile platform is a single-chip microcontroller. The function of this component is continuously information receiving from the sensor system, processes these data in accordance with the task, taking certain logical decisions and, as a result, generating the appropriate control pulses on the elements of the electric executive system;

1. The peripheral component between the microcontroller and some electrical actuators is the motor control device responsible for moving the mobile platform over the exploring terrain.

The sensor unit also has two components:

1. A sensor for realizing the detecting of a person function. Usually a person's search is carried out by the biometric characteristics. This search is carried out with the day and night vision cameras. In most of cases, this method is justified by the necessity to see the situation inside the blockages of buildings that surrounds the victim, as well as assess the real state of the person and the threat of collapse. However, these rescue robots are usually manipulated remotely, which does not characterize the robot as an autonomous platform. In the authors’ opinion, the most universal biometric sign of a
person is the temperature of his body. A person's search by their warmth does not have the disadvantages that are inherent in the search by sound, movement and breathing because of a person heat radiation under any conditions, if he is alive. Thus, the measurement of the continuous human thermal radiation is an ideal tool for they search;

2. A sensor for implementing a detour and overcoming obstacles by a mobile platform. It is designed to recognize obstacles in the way of the mobile platform, and to take a microcontroller decision on how the platform should overcome this obstacle. If obstacles are insignificant, then the platform moves them, and if there is a need to round these obstacles, then the platform should do it successfully. If there is no way to bypass and overcome the obstacle, then the platform should completely turn around and start otherwise trajectory.

The executive electric unit is divided into two components:

1. The electric drive. In this mobile platform, there are two electric drive systems, one of which is responsible for the direct movement in the mobile platform space, and the other - for scanning the visible space. The operation of the second motor system directly depends on the microcontroller control signals, while the control signals for the engines of the first system are interpreted via a special driver.

2. Annunciator device. These devices are designed to demonstrate the current point of the scanned space by the mobile platform and to signal about detection of a living person at this part of collapsed buildings and hard-to-reach premises. The alarm can be both light and sound warning, enough power to enable the rescuers to react to it. An annunciator device is managed by a signal of the microcontroller.

The mechanical executive components unit includes a chassis designed to move the platform through the terrain. This chassis is a rugged case with holes for fixing various kinds of devices, including electric motors of a mechanical drive. The executive unit includes also a mechanism for surrounding space scanning, which also fitted out by electric drives.

3. Results and Discussion
The literature sources [2-4,6-11] analysis was carried out, taking into account the fact that the structures for the creation of walking robots were not considered initially, for the mechanical basis, a chassis variant with a crawler drive was chosen. The authors’ robot was equipped with two electric motors to use the chassis when moving the platform. Scanning the environment was realized using two servos. As the electric motors for moving the mobile platform, geared motors of direct current were used. The mobile platform was also equipped with a pair of geared motors (DG02S), the gear ratio of which will be a trade-off between the output speed of the shaft and the torque.

According to the selected hardware and modular structure of the mobile platform processor system, the central element of the circuit that connects all the elements of the processor system is the microcontroller based on Arduino platforms. Namely the off-the-shelf debug board of the controller IteadunoUno v1.0. is based on the microcontroller ATmega328.

A modular structure describing the course and logic of sequential implementation of these two basic functions of the experimental model of the mobile platform is presented in Figure 2.

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**Figure 2. Modular structure of the pilot model management program for the mobile platform**
In accordance with this structure, the program is built on the sequential execution of three modules. The program presettings unit. In this module, all the required presettings for the further execution of the program are implemented. These presets are applied once as a connection to a program of various libraries that simplify the programming process, designate constants, variables, indicate the initial conditions of certain elements; for example, the setting of certain initial angles of the servo drives of the tower, as well as the initialization of signal terminals of various devices, and methods communication of these devices with the controller.

After all the necessary presets were done, the program proceeds to the irregularities bypass unit. This module is executed for a specified time, while the mobile platform moves through a certain investigated area. On expiration of irregularities bypass time, the mobile platform stops [18].

Further, the program proceeds to the next module. During the third module execution, the mobile platform stands still, and with the help of the servo tower it performs scans of the surrounding space, both horizontally and vertically within the operating angles of the servo drives. The measurement of the temperature of the object in each scanning position is carried out and if the value of this temperature corresponds to the temperature of the human body, then with the help of the piezo-radiator an audible warning begins that the person was found. After that, the program is looped on this alert, and the scan position is stored to indicate the direction in which the person was detected. Exit from this unit in such case is provided only by hardware, by resetting the power of the mobile platform. If after the scan of the surrounding area, no one was found, the program returns to its original position to the obstacle-avoiding module and the mobile platform continues the study of the territory.

The chart of the algorithm for irregulars passing is not presented because of its large volume. This subroutine is responsible for moving the mobile platform for some time, after which the microcontroller moves on to the next subroutine - scanning the surrounding space for human presence. The work of the bypass routine is based on the analysis of data obtained from the ultrasonic sensor distance.

A chart of the algorithm for the subroutine scanning of the surrounding space for human presence is shown in Figure 3.

An incremental-phased installation and testing of the experimental mobile platform model was carried out after functional simulation. First, the executive system was assembled in the form of a chassis and electric motors together with the controller board and the driver board of the motors. Next, an ultrasonic sensor and a temperature sensor were connected to the controller board, after which they were initialized. The last stage of the assembly was the connection of the executive and information management systems together, as well as the connection of warning elements.

After assembling the mobile platform, a control program has been developed to perform two basic functions, namely, to bypass obstacles and run the subroutine of scanning the surrounding space to search for a person by its body temperature.

The dimensions of the experimental model were 200 mm in height, 250 mm in width and 150 mm in length. When testing the experimental model, the block of obstacle clearance was tested in a room consisting of three rooms with obstructions and obstacles of a height of no more than 25 mm, which is half the height of the crawler wheel.

The space scanning unit for finding a living person determined the temperature of the radiated heat at a distance of the maximum range of the thermal imager. Next, the experimental model stopped and sent an alarm signal about a living person detecting.
Figure 3. The algorithm of the surrounding space scanning for human seeking

4. Conclusion.
As a result of the conducted research, the experimental model of the robot-rescuer mobile platform was created and tested. The prototype of small dimensions completely fulfilled the tasks assigned to it. The developed design and software can be implemented in different shape-factors, which in turn widens the scope of its application. Setting the thermal imagers to determine in another temperature range will make it possible to use robot for animals rescue. Also, the result of the experiments was information that can be used for further upgrades of the mobile platform.

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