Orıentatıon, navıgatıon and control methods of mobıle robot platforms

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Abstract
Specialized robotic complexes are used to search for certain objects, collect information about them, pre-process them, as well as exert a controlled influence on these objects. Such objects can be in various, sometimes inconvenient or dangerous places for people, as well as in unforeseen situations. It is characterized by complex, flexible operational algorithms for xrtk, a high degree of autonomy and a significantly higher data yield compared to irtk.
Key Words: Mobile Robot Platform, Robotic Complex, Orientation, Navigation, Control
The intensive development of robotics at the beginning of this century is primarily related to giving high spatial mobility to their main elements - robots, which is one of their main differences from the limited mobile robotics systems of the last century. , or is aimed at performing difficult tasks. Examples of such tasks include: performing military and police tasks, working in space, monitoring dangerous technological processes, diagnosing difficult-to-obtain technical products, working with explosive, toxic, radiation substances, working in aggressive or extreme environments, etc. Such tasks with the emergence of the concept of collective use of several mobile robots combined with a single goal function within the framework of an adaptive action algorithm, which involves the autonomous operation of robots and their interaction with the main computer, human-operator or other robots related. Depending on the purpose of the robotic complex and the tasks assigned to it, it can be conditionally divided into specialized and multifunctional complexes. Specialized robotic complexes are designed to perform monotonous, often repetitive operations. Such complexes are widely used in production, construction industry, agriculture, transportation, household and modern technology as intelligent tools.
Structure of the robotics platform. Let's call a set of mobile robots operating under a single control algorithm a robot platform. The need for interaction has a significant impact on the structure and tactical-technical nature of the main elements of mobile robots in rtp. These elements include, among others, orientation sensors (technical vision, pattern recognition, position stabilizers, adaptive navigation).
generalized scheme of the robotics platform.
The scheme shows the generalized structural scheme of the robotics platform (rtp). The central elements of this complex are the "Management System" and The "İnformation Provision System".
The tasks of the intelligent system (is) and management system include:
- to formulate management procedures of the executive system;
- support for control outside of a human operator or a specialized automated control system;
- implementation of management algorithms, as well as adaptation of these algorithms to a certain extent in accordance with current data (signals) from the information security system.

The hardware base of the intelligent system consists of universal or specialized microprocessor sets with internal or separate analog-to-digital converters and digital-to-analog converters, communication devices, non-volatile memory elements.
The information provision system performs the following tasks:
- Reception of signals from various specialized sensors with the subsequent transformation of these signals into a current information description of the state of the environment and other objects in it;
- assessment of information change dynamics;
- determining the results of the robotic platform's impact on the environment;
- correction of the robot platform operation algorithm according to the current parameters of the information image.

A set of sensors together with their signal converters and a high-performance computer (information imager) make up the robot complex. These sensors are different. Optical-electronic converters, laser and ultrasonic distance measurements, tactile sensors, inductive and capacitive sensors are mostly used. The communication system and executive complex are auxiliary structural elements of the robot platform. The communication system is responsible for connecting the robot platform with a single control center, other robot platform or technological equipment. This connection must be operational (provide real-time interaction), noise-resistant, which will allow the robotic platform to work in conditions of noise and non-noise interference of natural and artificial origin. Rapid communication with the operator or other robotic platform in addition to the dialogue, the communication system should provide external control of the current state and operation of the systems with the robotic platform, diagnosis of malfunctions or malfunctions in the operation of the robotic platform, regular or episodic adjustable checking of the systems, and the construction of the robotic platform with the platform.

Autonomous orientation and navigation methods with a robotic platform. Current methods of autonomous orientation and navigation of mobile robots are based on the use of information continuously provided by the information support system to the command and control system. The sources of this information (id) can be very diverse, but in most cases they are either internal or external. Idp rtp provide for receiving information about their coordinates, movement characteristics and other participants from external information sources. The work is based on the use of internal (own) hardware. Passive orientation and navigation tools include satellite systems (GPS, GLONASS, Prospective Navigation Systems Of Europe, China), location markers (Coordinate Beacons). Systems based on movement on reference points provide the best indicators in terms of movement accuracy in a rectangular or three-dimensional space with a robotic platform. However, this method is applicable only for a limited (mostly closed) space; it is difficult to use for several robotic platforms operating close to each other. Satellite systems are widespread and currently being successfully developed. However, when solving the problem of determining the coordinates of a mobile robot platform while moving along a complex route, the accuracy of such systems is not always satisfactory. In satellite systems, the main factors that lead to a decrease in the long-term accuracy of the determination of coordinates with a robot platform are: changes in the orbits of satellites, the access of the robot platform to signals from satellites the appearance of temporary obstructing objects, the interference effect of the earth's atmosphere, multiple reflections and interference of radio waves, soils, repeated retractions and interference of radio waves.

Active data sources for robotic platform navigation systems are widely represented by inertial navigation systems. Inertial navigation systems can be conventionally divided into systems that do not use additional information about the external environment surrounding the robot platform and systems that take such information into account. A classic example of inertial navigation systems is the position of the object relative to some initial (conditional zero) position in a given coordinate system and the moment of the applied forces, are mechanical gyroscopes and accelerometers that allow measuring its speed and speed. The main drawback of inertial navigation systems is the continuous accumulation of errors during its operation, as well as a sharp decrease in efficiency in situations where the object's velocity vector and its modulus change dramatically during the movement process. In addition, inertial navigation systems cannot provide information about other (often interfering) objects surrounding the robot platform. Therefore, inertial navigation systems can be used on the robot platform together with specialized sensors that allow obtaining additional information about the environment in which the robot platform operates. Trying to do. Environmental sensors are different. These can be force sensors (interaction sensors in contact with other moving objects or a fixed obstacle), various radiation sensors (ultraviolet, optical, infrared, radiation, radio wave, ultrasound), distance meters (optical and ultrasound).

Force sensors include pressure sensors and bending sensors. Their working principle is based on the change in the resistance of the conducting medium during bending or twisting. Often, such sensors are located along the protruding perimeter of the robot platform.

Radiation sensors are so diverse in terms of working principle and practical application that they can even be discussed separately. In the framework of the article, we will talk about their special type of video cameras. In general, their number is not limited on the robot platform. Navigation systems that use video cameras to position the robotic platform in the environment are among the most common and versatile systems. Video cameras are effective both when moving with a robotic platform indoors and when used outside the bounding box.

The structure of such positioning systems is similar to human vision in many ways. Often, binocular structures are used, which allow building a three-dimensional model of the environment of the robotic platform based on the comparison of images obtained from two spatially separated observation points. It is possible to use more than two video cameras on one robot platform. This approach allows to increase the efficiency of obtaining information about the environment in various directions, as well as to achieve its higher adequacy. But the advantages of a multi-camera robotic platform are significantly offset by a sharp increase in their price. It is possible to design a robotic platform with a single video camera. Moreover, even in this case, there are fundamental opportunities to obtain voluminous information about distant objects or obstacles. At the same time, the robotic platform the cost is significantly reduced. However, positioning systems using video cameras are not without drawbacks. As a complex, technically and structurally rich information conversion system, the video camera is exposed to various mechanical, atmospheric, electromagnetic and other interferences. Also, there are great difficulties in receiving, storing, processing and transmitting the large amount of data contained in the video image. In particular, these difficulties are associated with the problem of pattern recognition of objects, not all of which are known a priori. Optical and ultrasonic rangefinders represent a large class of active positioning and navigation tools. Optical rangefinders (lidar - light detection and ranging) are active optical systems that use the phenomenon of light reflection, as well as its scattering in transparent media. The principle of operation of lidar is similar to the operation of radar in many ways. The directed beam of the emitter is reflected from research objects or obstacles and returns to the point of radiation, where it is caught by a sensitive sensor, i.e. the receiver. Due to the short wavelength of light vibrations (rays), it is possible to fix reflective objects with small geometric dimensions, determine the distance to them, and estimate the scattering intensity of light rays in transparent media. The large number of factors of multidirectional scattering of light waves complicates the task of analyzing their propagation medium, the distribution of various objects in it, and the distances from the robot platform to these objects.

The source of probing radiation is either special lasers or leds. Lasers, characterized by coherence, high density and instantaneous power, are used when the distance to the studied objects is large (ten meters or more). It is possible to use led illuminators in closed areas (rooms, playgrounds, large equipment, etc.). Optical radiation can be implemented in the form of short optical pulses (for relatively large distances) or in the form of amplitude-modulated continuous oscillations (in the case of small distances from the robot platform to the studied objects).

To obtain a three-dimensional model of the space surrounding the robot platform, scanned optical emitters of machine vision are used, which create a two-dimensional and three-dimensional picture of the environment, as well as allow analyzing propagation characteristics. Various scanning heads are used to scan the directional radiation in a plane. In them, the optical emitter and the receiver of reflected (scattered) oscillations are stationary, and the scanning movement is achieved by the rotation of the mirror reflector, which is synchronized with the help of special fiducial marks.

Ultrasonic methods for orientation of mobile robots. Ultrasonic orientation methods for mobile robots are being intensively developed as the element base and technologies for generating, emitting, receiving and processing acoustic signals are improved. There are active and passive ways of orienting mobile robots using single and group ultrasonic sensors.

The passive method involves collecting signal data from stationary ultrasonic sensors and using wi-fi, bluetooth, etc. Such as receiving data through standard communication channels and then transferring it to

the robot's mobile platform. At the same time, along the perimeter of the space where the robot moves, there are several acoustic sensors (their number depends on the geometric features of the space, the presence of obstacles and their acoustic properties, etc.). These sensors allow you to measure the coordinates of a moving or stationary object. The measurement results are transmitted to the mobile object, which uses it to correct its movements in a limited space. This approach is distinguished by high accuracy and positioning efficiency, but it is very expensive and not flexible enough. The active method involves the use of various acoustic sensors on the robot platform, both in a fixed position and in a moving position, which involves scanning the space in azimuth. This method is more promising and suitable for most real tasks that require autonomous navigation of mobile platforms. In the simplest case, two ultrasound sensors working on the principle of echolocation, which emit and receive ultrasound waves reflected from objects, are enough. To ensure the autonomous movement of the robot, the results of measuring distances to obstacles with an ultrasonic sensor are used both in the stationary state of the robot and when moving along the selected route. The presence of an obstacle is calculated by the robot's analyzers based on the time measurement of the distances from the emitter (receiver) to the obstacle in the case of a stationary platform, as well as during its movement. In this case, in the case of mutual movement of the platform and the obstacle, the doppler effect occurs, which is taken into account in the calculation algorithms for controlling the movements of the platform. In some cases, such algorithms involve sectoral or circular rotations of the robot's sensors in order to more accurately consider the location of the obstacle and choose the optimal path of movement.
The use of phase-sensitive sensors of ultrasonic rangefinders in mobile robotic platforms is of great interest. Such measurements are especially effective in creating control subsystems of several platforms operating simultaneously. This approach allows designing a multi-channel control system that takes into account the doppler effect in each channel.

Complexization of orientation and navigation subsystems in mobile robots.the development of new materials, microelectronics elements, precise mechanical nodes, optics in terms of cheapening, miniaturization, reduction of energy consumption, increase of reliability allows to set and solve tasks of complex use of several single-cell, as well as various navigation and positioning devices on one robotic platform. Unequivocal criteria for choosing the number and types of such devices have not yet been formed. However, all these criteria are based on a single principle.

An example of such an approach is a study that proposes the joint operation of three pairs of ultrasonic sensors tuned to receive signals of different frequencies from reference emitters whose coordinates are known in advance or can be transmitted via intercom. Mechanically, all three pairs of sensors are located coaxially on the robot platform, but rotate around a common axis independently under the influence of individual motors and control subsystems. Thus, the system of these three pairs of sensors allows to determine in real time the current values of the orientation angles of the sensor pairs to the corresponding reference emitters. This, in turn, allows to calculate the current position and orientation of the robotic platform in a certain limited space using the triangulation method.

The work proposes a complex method of robotic platform navigation, which involves the combined use of tactile and ultrasonic sensors. This approach made it possible to reduce the energy consumption and cost of the rtp, as well as to significantly improve its tactical and technical characteristics, compared to the use of the same type of positioning and navigation sensors.

Conclusion

Modern robotic platforms are complex cybernetic devices designed to solve various tasks mainly in offline mode. This depends on the robot platform's purpose, operating conditions, failure risks, range, etc. Depending on it, requires the development of different hardware and software for positioning and navigation. Sensors vary in terms of their physical working principles as a component of hardware and the way they are organized as part of a robotic platform. Each of the existing types of sensors has its own advantages and limitations, which makes the task of their integrated use within a single robotic platform urgent. Taking into account the modern state of the component base, materials, precise mechanical elements, optics, means of communication, obstacle-resistant coding, software technologies, this kind of complexification allows to significantly improve the tactical and technical characteristics of the positioning and navigation systems of the robotics complex.

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