

Walking systems of robots

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ABSTRACT

Although wheeled vehicles dominate today, there is know that stepped locomotion systems have significant advantages on uneven surfaces. They use only a few points of contact with the surface for support, unlike wheeled or tracked machines that create continuous contact. In addition, walkers are significantly less disruptive to the soil, which can be important in certain areas. However, these advantages are accompany by the complexity of the design. A large number of degrees of freedom requires careful layout, the development of powerful drives and special mechanisms that reduce shock loads. The control system must not only process information about the environment, but also make decisions about movement and control their implementation. The main problem of walking robots lies in the development of a control system since the existing experience in creating complex automatic systems cannot be directly apply to control such devices.

The creation of industrial robots capable of replacing humans in many areas of modern production, as well as automatic systems that can be used in conditions dangerous for humans, is an urgent scientific and technical problem. One of the important classes of robots are walking robots designed to move over difficult terrain.

Keywords: stepping systems, robots, review, robotics.

1. INTRODUCTION

Walking robots can move over rough terrain inaccessible to conventional wheeled vehicles. Walking robots usually created for this purpose. It is worth noting that the projects of stepping machines were implement in almost all technologically developed countries, the USA, Japan, England, Finland, Belgium, Germany, Spain, and others.

In general, the idea of using walking robots is consider by many researchers. The choice of structures depends on the tasks set before the walking machine. The possibility of using a simplified design, reducing the mobility of the limbs, simplifying control systems, ensuring movement arises in cases where the robot is not required to move on complex surfaces, in cases where the operator takes over part of the control. In tougher conditions, when it is necessary to act fully or partially autonomously and when the state of the support surface is unknown in advance, the robot must have a design with a greater degree of limb mobility. This leads to the need to build a complex management system.

The specific level of automation of the motion control of the stepping machine depends on the purpose of the machine and the conditions of its use. Thus, information robots working in extreme conditions, with terrain unknown in advance, must use complex on-board computing complexes, and for technological walking machines, the use of such systems is not advisable. The tasks of the control system become the management of a large number of degrees of freedom, ensuring the necessary kinematic and dynamic parameters of walking devices, and in the case of autonomous robots, the tasks of navigation and orientation in space are add.

The software of control systems determines the properties and characteristics of walking robots. The high uncertainty of the surrounding environment limits the possibility of using rigid limb control algorithms. It is obvious that the control system must include devices for determining the position of the robot body and its limbs in space, control of the support surface, evaluation and selection of the movement route, devices for expanding the functionality of the robot, performing any service functions. the

most promising solution is to borrow algorithms for the movement of limbs from representatives of living nature (insects, mammals, arthropods). However, simply copying the algorithms and trajectories of the limbs is not enough to ensure the movement of the robot on complex terrain.

2. DESIGNS OF WALKING ROBOTS

The body of the HexCrawler robot is made of aluminum (Fig. 1). The drive is carry out with the help of 12 servomotors, which allow it to develop high speed. It has 3 groups of limbs. Each group consists of two limbs. One group performs only a support function. The other two are use to provide movement. Each of these groups is drive by one servo. The kinematics of the robot is greatly simplified, as is the control system, providing movement. As a result, maneuverability is reduce, the requirements for surface quality, on the contrary, are increased. The robot's walking system is similar to the spider system.



Figure 1. HexCrawler

AlphaDog is a robot that can transport up to 180 kilograms of payload (Fig. 2). The robot is equipped with a video surveillance system consisting of a pair of stereo cameras installed in the robot's head. The robot was also equipped with a "LIDAR" range detection and measurement system.

The walking system of the robot is similar to the support system of the dog.



Figure 2. AlphaDog

MANTIS is a walking spider robot that was create over four years at Micromagic Systems (Fig. 3). Its curb weight is 1,900 kg, its height is 2.8 m. It is equipped with a 2.2-liter 50-horsepower Perkins turbo diesel, the power of which is aim only at creating the necessary pressure in the hydraulic system, which drives the car with the help of 18 hydraulic cylinders on six "feet". The central control unit is based on the Linux operating system with the HexEngine software and a variety of sensors.



Figure 3. MANTIS

Robot Xinghe Nr.1 was develop by a team led by Li Qindu, a professor at the College of Automation of Chongqing University of Telecommunications (Fig. 4). Xinghe Nr.1 was able to travel 134.03 km in 54 hours, which is twice that of the Ranger on a single battery charge. The robot took 340,000 steps, while the speed of its movement was only 2.4 km/h. For this, he spent 0.8 kWh of energy, demonstrating his high-energy efficiency.

Cassie robot was develop by Oregon State University spin-off Agility Robotics and was introduce in 2017 as a platform for robotics research (Fig. 5). Since then, Cassie has continued to make great strides, showing impressive progress in 2021, running 5 km in just over 53 minutes.

In general, the idea of using walking robots is consider by many researchers, and the choice of structures depends on the tasks set before the walking machine.



Figure 4. Xinghe



Figure 5. Cassie

References

- [1] Andrienko V. O., Bondarenko M. O. Robotic systems in technical education. Information technologies in education, science and technology: thesis. IV International science and practice conference, Cherkasy, May 17-18, 2018. Cherkasy: ChDTU, 2018. P. 43-44.
- [2] Sukhoruchkina O. M. Information support of intellectualized robotic complexes. The state and prospects of the development of informatics in Ukraine. Kyiv: Naukova Dumka, 2010. P. 547-561.
- [3] Nick Lavars. Bipedal Cassie sets Guinness World Record for robotic 100-meter sprint. Review September 27, 2022, URL: <https://newatlas.com/robotics/cassie-bipedal-robot-guinness-world-record-100-meters/>.
- [4] Mishchuk D., Boychenko A. Development of the concept of control system work for plaster works based on neural network. *Girnichy, budivelni, dorozhni ta meliorativni mashini*. 2019. No. 93, P. 46-60. URL: <https://doi.org/10.32347/gbdmm2019.93.0501>.