Design of walking robot model moving on vertical areas

Opracowanie modelu robota kroczącego poruszającego się po powierzchniach pionowych

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The aim of this article is to present a mobile robot project designed to move on surfaces with an angle of inclination to 90 degrees. It will be a robot modeled on gecko. The main functionality of the robot, which is to move over inclined surfaces, will be realized using specially designed paws with adhesive material on the underside. Two walking modes will allow the operator to move robots limbs freely or walk to the desired direction.
KEYWORDS: robotics, walking robots, mobile robots, rapid prototyping, adhesive material

Mapping of nature is a very common source of inspiration when creating inventions or solutions that are used both in industry and everyday life. Starting from the wheel (the most groundbreaking invention in human history), whose shape corresponds to the sun, the moon, or the human pupil, up to the plane that was created by trying to build a machine that equals the ability of birds to fly. Today's scientists around the world are trying to use a variety of animal capabilities (such as weaving webs, moving at high speed and agility in difficult terrain) for example for military or industrial purposes. Machines that map animal kinematics are, among others, mobile robots. One can highlight walking, crawling, flying and flying robots. The most complex structure (due to the need for the mechanization of the limbs) are walking machines, able to move in a different environment. Examples include Boston Dynamics solutions, tested both in laboratory conditions (flat surfaces) and natural (in the woods, on the rocks) - including obstacles. The construction of the limb must provide static and dynamic stability of the robot, especially as it is to move at a speed not lower than the speed of the foot (due to the specificity of the projects, e.g. military).

Overview of walking robot designs

In the case of walking robots, the designers concentrate mainly on the construction of these machines, i.e. on the number and configuration of the legs and on the way of movement. Due to technological limitations mapping method move should allow for a functional design, while its simplicity.

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There are three basic models of walking robots leg configuration (fig. 1). At first, the typical mammalian limb are positioned under the body and the two corresponding main joints for movement in most cases are located in one plane perpendicular to the body. In the second configuration of the legs, occurring in reptiles, the knee joint is outside the body of the (reptiles are not able to walk with the knee joint in the body), and the hip joint is located on the side surface of the body. In the third model, configuration, legs characteristic of insects, the hip joint is positioned on the side surface or the upper body, and the first joint of the limb is above the body. From an economic viewpoint, the modeled model of mammals is cost effective energy (the smallest loss of energy to counteract the force of gravity), and the model modeled on insects is the easiest to implement (because of the good stability - with the number of legs greater than four, and the wide distribution of the support points). The large polygon of the support, created by combining the leg contact points with the ground, and the relatively small body mass, allow the reptiles and insects to move around the sloping surfaces (it is even possible to ignore the fact that both reptiles and insects have specially ended limbs which allow strong grip surface - branches, leaves, rocks, etc.).

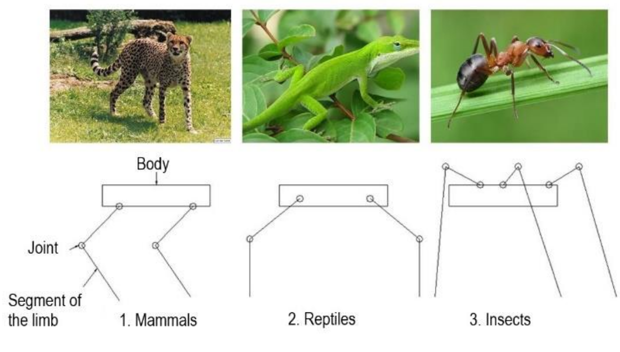

Fig. 1. Models of legs of walking robots

Many variants of walking robots are being developed, using natural patterns and different leg configurations. Talking style is rarely used due to the greatest complexity of movements (in the movement of reptiles, it is usually important to work with the body with the tail). The other two models were used while the configuration of the legs to create many prototypes of robot-mammals (e.g. robotic cheetah - fig. 2) and robot-insects (e.g. robot-ant - fig. 3).

Robots-reptiles are not numerous - probably due to undiscovered functionality in people's everyday lives. An example of such work - taking into account the criterion of configuration feet - is Pleurobot (fig. 4).

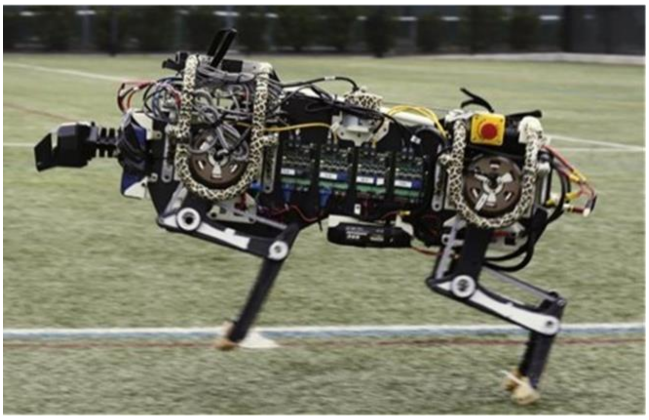

Fig. 2. Robot-cheetah by Boston Dynamics [1]

Fig. 3. BionicANTs FESTO [2]

Fig. 4. Pleurobot from Biorobotics Laboratory (BioRob) [3]

Assumptions to a robot project

The main aim of the project is to develop and then to develop a mobile robot model with the ability to move on smooth surfaces (e.g. glass or lacquered wood) with a slope of 0° to 90°. The AirStick Microsuction Tape (fig. 5 and fig. 6) will be placed on each of its limbs and on the tail to ensure adequate traction of the robot.

The material used has a sponge structure, so the adhesion is obtained in part by the vacuum produced when the material is pressed and partly by the adhesion produced on the smooth surfaces between the cavities. Such a structure causes the material to be attached under the influence of low pressure and is resistant to the transverse force.

Preliminary studies have shown that a sample of 1044 mm^2 is capable of holding a weight of 1.75 kg (under shear load), giving an adhesion of 1.67 g/mm^2. Adhesion tests will be continued for shear and tensile strength.

Fig. 5. Sample of AirStick Microsuction Tape

Fig. 6. AirStick Microsuction Tape (left: cross-section, angled projection, vertical view from the adhesive side and vertical view from the mounting side)

According to the structure of the biological pattern (gecko), the robot will move through four flukes and tail, thus ensuring high stability - both static and dynamic. The model for the most part will be executed in rapid prototyping technology.

Robot construction

The limiting factor to the mobile robot's potential is the limb. Fig. 7 shows a model diagram of the preliminary model of so-called adhesive feet. Underneath, there will be glued adhesive material, which grips the flat surface. The limb will be composed of two main segments responsible for the progressive movement, jointed by joints, and one side member that directs the vertical movement. It was assumed that the limb would be made of elements produced by rapid prototyping, which would allow for complex geometry and optimized mass.

It is necessary to control the robot from each leg separately, so the walk can be fitted to current needs and adequate adhesion strength.

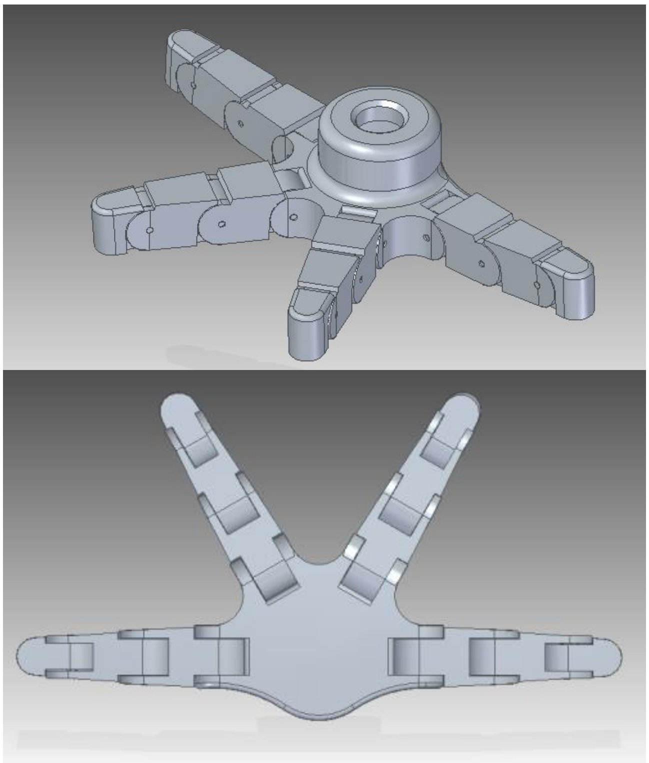

Fig. 7. Surface gripper

Control system concept

The mobile robot control system will be built using the Arduino platform. Control of individual robot limbs equipped with servomotors will be implemented using the PWM method. To ensure the stability of the robot on the inclined surfaces, it will be necessary to develop an algorithm that controls the individual limbs, including the attachment of the paws in contact with the ground. This means that the control will have to be done in a synchronous manner for each of the robot limbs. For the study, it plans to develop two basic modes of operation (move) the robot. In automatic mode, the operator will issue a forward/backward and a right/left command, but will not deal with the movement of each limb individually, because the walking algorithms will be programmed. In manual mode, the operator will be able to control separately each limb and tail, which will allow to test the behavior of the robot in unusual conditions.

The implementation of tasks related to the construction of a prototype of a robot requires solving technical problems such as:

- selection and execution of the four-legged driving system and the tail (stabilizing function), allowing the robot to move on surfaces with a tilt angle of up to 90°,
- selection and execution of a control system using a Bluetooth/Wi-Fi, which ensures a stable connection between the robot and the operator,
- execution of the sensory system, which allows to collect information about the robot working space,
- protecting the prototype against damage when falling from a height.

The tests using the final model will aim at: determining the functional parameters of the robot and the parameters of its limb and tail to the ground, checking the adaptability of the rolling system to the changing environmental conditions and the effectiveness of the control algorithm.

Conclusions

Nowadays, walking robots are not used in everyday life in Europe. So far, the functionality of robots based on reptiles has not been discovered. The project of rolling robot on inclined surfaces may contribute to the popularization of such machines in Poland. Considering the use of innovative materials such as the AirStick Microsuction Tape, as well as Arduino's rapid prototyping and control technology, this is the first such project in Poland.

The article contains a description of a project co-financed by the Jaroslaw Dąbrowski Military Academy of Technology in Warsaw.

REFERENCES

1. Opracowanie własne.
2. www.bostondynamics.com/robot_cheetah.html_(2017).
3. www.festo.com/group/en/cms/10157.htm_(2017).
4. www.biorob.epfl.ch/cms/site/biorob/lang/en/pleurobot_(2017).
5. Opracowanie własne.
6. Opracowanie własne.
7. Opracowanie własne.