MODELING AND CONTROL OF A HYBRID WALKING ROBOT ON IRREGULAR, UNSTABLE AND VIBRATING GROUND

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Last decades have brought significant importance of mobile walking robots in engineering applications and they have been extensively studied in the literature [1]. When the robot's legs are controlled with a degree of autonomy, it can move within its surrounding environment and perform scheduled tasks. Among a large number of the most popular crab-like robots, also robots with leg structure modelled based on the anatomy of mammals can be found in the literature and engineering applications. For instance, an interesting literature reviews regarding the most popular crab-like and/or mammal-like multi-legged robots are presented in papers [2-4].

About a half of the Earth's land surface is not available for wheeled vehicles, but it can be accessed by humans and animals that can walk in those difficult and irregular terrains [5]. This is why, nowadays, there is a lot of interest in various kinds of robots that use legged motion inspired by walking animals met in natural environment. This type of motion allows to overcome obstacles, move in an omnidirectional manner, as well as access uneven environments, in comparison to crawler or wheeled robots. As a result, such constructions are especially useful for exploration of unknown terrains, both on the Earth and other planets.

Unfortunately, due to the simultaneous coordination of all robot's legs, they are challenging in terms of controlling both their locomotion and all degrees-of-freedom of the robot's body, especially on irregular, unstable of vibrating ground. In order to ensure all of the above-mentioned control possibilities required for autonomous walking robots, in this study we considered first a general, both kinematic and dynamic models of a multi-legged hybrid robot with a crab-like and/or mammal-like legs. The simulation model of the robot presented in Fig. 1 was developed and investigated numerically in Mathematica software. This model is useful for virtual experiments to visualize the locomotion process of the robot.

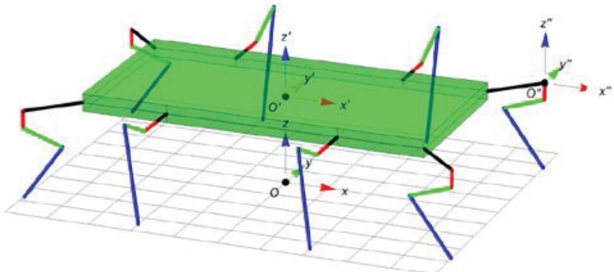

Fig.1. Simulation model of a hybrid walking robot created in Mathematica

A novel, relatively simple and efficient model of gait was employed and tested in order to drive the robot’s legs. A simple algorithm responsible for the initial, rhythmic and terminal phases of the robot gait has also been introduced. Some interesting time histories of the kinematic/dynamic locomotion parameters of the robot during walking on a planar surface were calculated, illustrated and discussed. The simulated results proved some advantages of the employed gait generator, including fluctuations in the robot’s body and the minimum value of dynamic stability margin of the robot during walking. However, it should be noted that in a real control system of the robot, some deviations can be present, for instance, caused by control errors and dynamics of drives installed in the individual robot's joints. We also considered more precisely control the position of the robot during walking in different directions. The presented algorithm can be used to simultaneous control of all robot's legs and control of all six spatial degrees-of-freedom of the robot's body, i.e. three rotations and three linear deviations. Therefore, the considered robot can be used as a full controlled walking Stewart platform. Furthermore, the control algorithm can also be successfully used to coordination and control all robot's legs on vibrating and unstable ground. For instance, this algorithm can be employed to stabilize the robot's spatial position when the supporting ground becomes vibrating and/or unstable. As a result, it will keep the robot stable and prevent it from falling over.

Concluding, it should be mentioned that the Mathematica software allows to communicate with different microcontrollers such as Arduino Uno or Raspberry Pi (see Fig. 2). Thanks to this, the developed simulation algorithms have been relatively simply adopted to control real construction of multi-legged robot. As a result, also some interesting experimental results have been obtained and discussed.

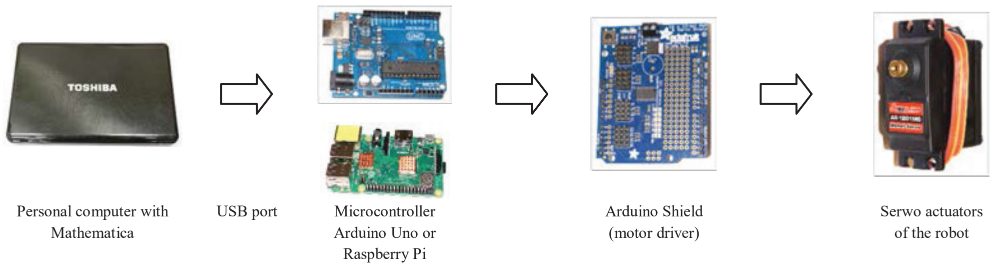

Fig.2. Control the robots' servos of a robot prototype using a simulation model developed in Mathematica

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