Brachiation robots : Trajectory of movement of a jumping brachiating robot

Andrei I. Bodrenko
http://bodrenko.com
bodrenko@bodrenko.com

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https://orcid.org/0000-0002-4618-3784
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Trajectory of movement of a jumping brachiating robot

A. Bodrenko

"Interactive Systems"Ltd., Volgograd, Russia; bodrenko@mail.ru

Abstract
The trajectory of movement, in the free flight phase, of the center of mass of the mobile robot during vertical jumping is obtained in this article

The methods of movement of a jumping brachiating robot were patented in [1]. We consider a mobile robot implementing vertical jumping in order to catch the holder by actuating the gripper (at the special moment of time) for brachiating purposes. We will calculate the velocity of the center of mass of the mobile robot implementing vertical jumping at the moment of beginning of the free flight phase.

Jumping brachiating mobile robot, which is a wheeled robot, comprises:
a mobile platform having an omnidirectional mobile mechanism; an onboard computer with an information storage device; a Wi-Fi network node equipment connected to the onboard computer; an electric battery; two video cameras; a gripper; a wrist on which the gripper is installed; a robot arm on which the gripper is installed.

The electric battery provides electric power to the mobile robot on which this electric battery is installed. Each video camera is capable of getting and transferring the images to the onboard computer of the mobile robot, on which this video camera is installed, for image processing at 1000 fps for 1024×1024 pixels. The onboard computer is capable of real-time image processing of the input images received from the two video cameras (at 1000 fps for 1024×1024 pixels, for each video camera). The real-time image processing is done by using software for computer vision systems, Linux-based real-time operating system, software for parallel computing, and software allowing applications to run on real-time operating systems. Thus, the onboard computer and the two video cameras connected to it form a real-time vision system.

Localization of this mobile robot is conducted continuously through the dead reckoning by using sensor fusion and analyzing information received from the video cameras and proprioceptive sensors of this robot.

The calculated trajectory of movement, in the free flight phase, of the center of mass of the mobile robot during vertical jumping is obtained from the following equation system:

$$y' = v, \quad v' = -g - (K/m) \cdot v \cdot |v|, \tag{1}$$

where: $y = y(t)$ is the calculated coordinate of the center of mass of the mobile robot at the moment of time t during vertical jumping; $v = v(t)$ is the velocity of the center of mass of the mobile robot at the moment of time t; m is the mass of the mobile robot; K is the air resistance coefficient determined by the properties of the environment, the shape of the mobile robot, and corresponding to the square of the velocity of the mobile robot; g is the acceleration of gravity. Wherein the air resistance coefficient K for this mobile robot is calculated approximately, for example, by using the video recordings of vertical jumping of this mobile robot, and with specified initial velocity not exceeding the value of 15 m/s.

For the equation system (1), the following conditions are considered:

$$y(T) = A, \quad y(L) = B, \quad v(L) = C, \tag{2}$$

where: T is the calculated moment of beginning of jumping; L is the calculated moment of closing the gripper in order to catch the holder (the calculated moment of time when the gripper of the mobile robot is actuated); A is the coordinate of the center of mass of the mobile robot at the moment of time T; B is the coordinate of the center of mass of the mobile robot at the moment of time L; C is the velocity of the center of mass of the mobile robot at the moment of time L. Note that the values A, B, C are given and L is obtained from (1) using (2).

We solve (1) with conditions (2) and obtain

$$L = T + (m/(K \cdot g))^{1/2} \cdot \arccos(\exp((K/m) \cdot (A - C_2))) - C_1/g,$$

where

$$C_1 = ((m \cdot g)/K)^{1/2} \cdot \mathrm{arctg}((K/(m \cdot g))^{1/2} \cdot C),$$
$$C_2 = B - (m/K) \cdot \ln(\cos(\mathrm{arctg}((K/(m \cdot g))^{1/2} \cdot C))).$$

Thus the calculated trajectory of movement, in the free flight phase, of the center of mass of the mobile robot during vertical jumping has the following form:

$$y(t) = (m/K) \cdot \ln(\cos((K/(m \cdot g))^{1/2} \cdot ((L - t) \cdot g + C_1))) + C_2,$$
$$v(t) = ((m \cdot g)/K)^{1/2} \cdot \mathrm{tg}((K/(m \cdot g))^{1/2} \cdot ((L - t) \cdot g + C_1)).$$

Therefore the velocity of the center of mass of the mobile robot implementing vertical jumping at the moment of beginning of the free flight phase has the following form

$$v(T) = ((m \cdot g)/K)^{1/2} \cdot \mathrm{tg}((K/(m \cdot g))^{1/2} \cdot ((L - T) \cdot g + C_1))$$

References

1. *Bodrenko A.* Method for movement of mobile robot in warehouse: Patent RU 2748441 C2 // The Official Bulletin "Inventions. Utility Models": Patents of the Russian Federation for inventions (ISSN 2313-7436). Vol. 15, 2021.