Chapter 3
Approaches to Development of Mechanical Design and Jumping Motion for a Wheeled Jumping Robot

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ABSTRACT

This chapter is dedicated to tackling the issues related to the design and locomotion control of a hybrid wheeled jumping monitoring platform. The studied robot consists of a body mounted on a wheeled platform and of a jump acceleration module. An approach to making design decisions regarding the structure of the investigated robot is proposed. To select the kinematic structure of the robot, classifications of possible variants of hybrid jumping platforms and accelerating modules are presented. Methods for controlling the function of the accelerating modules and the analysis of their work is carried out. Various implementations of jumping motion are discussed; these implementations are characterized by different combinations of relative links movements during various stages of motion. Each of the proposed jump motion types requires the development of a control system, which is also discussed in this chapter.

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INTRODUCTION

The application of robots in performing tasks, traditionally imposed on people, results in lower costs and risks, and improves the quality of the accomplished work. The most typical example is the tasks of monitoring and survey of hard-to-reach areas. The use of robots for solving such problems can provide significant economic and social effects, allowing to automate a number of complex, labor-intensive and potentially dangerous activities, such as preparation and updating of maps and three-dimensional models of emergency situations, collection of data on the state of the environment in areas subjected to biological or radiation contamination, continuous monitoring of the environment, air and soil sampling, etc.

Therefore, one of the urgent tasks of modern robotics is the creation of small-sized monitoring devices with high mobility and the ability to move around complex terrain areas with debris and obstacles. Such devices include wheeled and tracked robots (Murphy et al., 2008; Kawatsuma, Fukushima, & Okada, 2012), walking robots (Yi et al., 2014; Calinon, Guenter, & Billard, 2007), crawling multi-link robots (Vorochaeva et al., 2017; Peters, Ahn, & Borkowski, 2002), flying (Tanaka et al., 2005; Vorochaeva et al., 2018) and jumping (Gilani & Ben-Tzvi, 2011; Tsukagoshi et al., 2005) systems. It should be noted that the dimensions of the obstacles that can be traversed are directly related to the design features and the dimensions of the robots (wheel radius, link lengths, ranges of relative angles, etc.). Flying and jumping systems have more opportunities to move on uneven terrain and can traverse a wider range of obstacles in size and shape. For flying systems equipped with propellers or wings, this range of obstacles is due to the thrust of the propellers or wings, while for jumping systems it depends on the takeoff speed and the inclination angle at which the takeoff occurs.

This study is focused on jumping robotic systems due to their advantages over flying devices. These advantages include better maneuverability and easier control when moving in confined spaces, as well as when moving between high-rise buildings, due to their lower exposure to turbulent air flows; jumping robots are also characterized by less noise and lower energy consumption.

The robot studied here is a combined system, including a body mounted on a wheeled platform with an acceleration module located inside, through which the jump is carried out. This chapter is devoted to general, basic issues related to jumping robots, and consists of the following parts: introduction of general terms and concepts of jumping motion, justification and selection of the combined wheel-jumping platform scheme, description of the design scheme of the device, description of the various variants of the jump implementation, development of the robot control system and the definition of permissible values ranges of the robot
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