862. Optimal design and experimental verification of a spherical-wheel composite robot with automatic transformation system

Kang Hou[1], Hanxu Sun[2], Qingxuan Jia[3]
Department of Automation, Beijing University of Posts and Telecommunications, 100876, Beijing, China
E-mail: [1]*houkang87@hotmail.com*, [2]*hxsun@bupt.edu.cn*, [3]*sdjqx@sohu.com*

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Abstract. This paper presents a design for a dual-mode prototype robot with the advantages of both a spherical robot and wheeled robot. A spherical robot has flexible movement capabilities, and the spherical shell can protect the mechanism and electronic devices. A wheeled mobile robot operates at high speed on a flat road. Its simple structure and control system has made it a popular choice in the field of robotics. Our objective was to develop a new concept robot capable of combining two different locomotion mechanisms to increase the locomotion stability and efficiency. The proposed mobile robot prototype was found to be capable and suitable in different situations. The exchange of modes between the spherical and the wheeled robot was realized by a structural change of the robot. The spherical-wheel mobile robot prototype is composed of a deformable spherical shell system, the propulsion system for the sphere and a wheeled mobile unit module. The exchange of locomotion modes was implemented by changing the geometric structure of spherical shell. The mechanical structure of the composite robot is presented in detail as well as the control system including hardware components and the software. The control system allowed for the automatic transformation of the composite robot between either of the locomotion modes. Based on analysis and simulation, the mechanism was optimized in its configuration and dimension to guarantee that robot had a compact structure and high efficiency. Finally, the experimental results of the transformation and motion processes provided dynamic motion parameters and verified the feasibility of the robot prototype.

Keywords: spherical-wheel robot, dual-mode locomotion, simulation and optimization, prototype experiment.

Introduction

With the continuous development of robotics technology, robots operate in an increasing number of different environments. As a result, the mobility of robots is coming to the attention of scholars all over the world. The multi-modal locomotion robot, which combines two or more kinds of robots in one body, has many locomotion modes to face different environments. Given the conditions of different application environments and tasks, this kind of robot can choose the optimal movement mode and deform itself to move in a stable and reliable manner. Multi-modal locomotion robots have been under extensive research and development in recent years. NASA Jet Propulsion Laboratory (JPL) developed a robot named Go-For, and this robot has wheels at the end of its legs [1]. This wheel-leg composite robot combined the high adaptability of the leg robot and high speed and efficiency characteristics of the wheeled robot. Automation Technology Laboratory in Helsinki University of Technology designed a new platform with hybrid locomotion capability. It is used mainly in an outdoor environment when doing work interactively with a human operator. The purpose of the hybrid platform locomotion system was to provide a rough terrain capability and a wide speed range for the machine at the same time [2]. AZIMUT in IntRoLab is a modular mobile robotic platform that addresses the challenge of making multiple mechanisms available for locomotion on the same robotic platform. AZIMUT has four independent articulations that can be wheels, legs or tracks or a combination of these