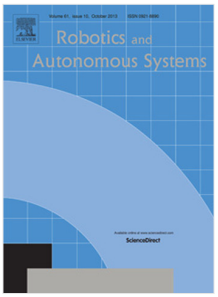
Accepted Manuscript



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PII: S0921-8890(18)30189-1
DOI: https://doi.org/10.1016/j.robot.2018.06.005
Reference: ROBOT 3044

To appear in: *Robotics and Autonomous Systems*

Received date : 7 March 2018
Revised date : 20 April 2018
Accepted date : 11 June 2018

Please cite this article as: L. Bai, J. Guan, X. Chen, J. Hou, W. Duan, An optional passive/active transformable wheel-legged mobility concept for search and rescue robots, *Robotics and Autonomous Systems* (2018), https://doi.org/10.1016/j.robot.2018.06.005

An optional passive/active transformable wheel-legged mobility concept for search and rescue robots

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Highlights:

- A novel transformable wheel-legged mobility concept for search and rescue robots is proposed.
- Circle-wheeled and wheel-legged modes can be passively or actively transformed with minimally actuators.
- Parameters optimization is conducted for transformation success rate and obstacle-negotiation capability.
- Experiment results validate the effectiveness of the proposed robot.

Abstract--- A novel transformable wheel-legged robot, namely Land Devil Ray (LDR), is proposed for search and rescue mission in complex terrains. Inspired from spatial folding mechanism and metamorphic mechanism, a multi-four-bar linkage transformable wheel-legged locomotion mechanism is proposed for LDR, which can transform from circle-wheeled mobility to wheel-legged mobility, or vice versa, for adaptability of different terrains. Aimed to minimize the robot actuators, the wheel-legged transformation is designed to be triggered passively when contacting the obstacles, or be actively driven without extra actuator by active triggering mechanism. The parameters of wheel-legged structure are optimized as well for an optimal transformation success rate and better obstacle-negotiation capability. A prototype of LDR robot is conducted, and its experiment results show that the proposed robot integrates the advantages of both wheeled and legged mobility, and has excellent performance in maneuverability, stability, maximum obstacle-negotiation height and mode switch process, such as transformation ratio as 1.88, transformation success rate as 100%, and ability to over obstacles 2.8 times as tall as its wheel radius. Lessons learned from the proposed robotic mobility and its results have general applicability to search / rescue robots, and other types of mobile robots as well.

Keywords: Rescue robot, Mobile robot, Wheel-legged mobility, Transformable wheel, Obstacle negotiation

1. Introduction

Small mobile robots with high maneuverability are highly demanded in various uncertain, unreachable terrains such as narrow space in damaged building after disasters, radiation environments and complex working field in wild terrains, etc. These robots enable researchers to obtain related information from far distance, and improve reconnaissance efficiency and disaster handling ability [1]. Currently, the wheeled mobility is the most common way for mobile robot since its high maneuverability and stability. However, this mobile mechanism is limited in climbing over obstacles. For example, the wheeled mobility can hardly overcome the obstacles higher than its radius of the wheel [2].

Various methods have been proposed to tackle these problems, for instance, special wheel configurations. The Epi.q series robots passively adapt their locomotion from rolling on wheels to stepping on rotating legs, according to ground conditions and obstacle presence, without an active control intervention [3], The Lazaro robot consists of a skid-steered wheels plus a 2-DOF caster-leg to cross different surface discontinuities, and this configuration is useful for improving vehicle stability on slopes [4][5]. However most robots with special wheel configurations have complex mechanical structures and low mobility efficiency.

Wheel-legged mobility concept with spokes and legs is a solution for the obstacle-negotiation limits of wheeled mobile robot. This concept combines the advantages of wheeled and legged mechanism. For example, the Whegs series hexapod robots are bio-inspired by cockroach mobile mechanism. The rimless, three wheel-legged spokes design enables the robot to climb the obstacles 1.5 times as tall as its radius [6][7]. The RHex series hexapod robots are bio-inspired by