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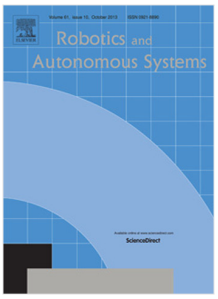

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Caster-Leg Aided Maneuver for Negotiating Surface Discontinuities with a Wheeled Skid-Steer Mobile Robot

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Abstract

Crossing surface discontinuities, such as ditches or curbs in urban environments, is a relevant navigation issue for ground mobile robots. This paper proposes a maneuver for negotiating surface discontinuities for a hybrid locomotion system consisting on a skid-steer wheeled vehicle with a single caster-leg mechanism. This maneuver is appropriate for gaps, steps, and ramps, both upwards and downwards. Furthermore, an analysis of tipover stability and steerability through the different states of the maneuver is performed, resulting in sensor-based stability margins that can be computed online. Experimental results have been obtained by means of realistic Simulink/ADAMS simulations and actual tests with the Lazaro mobile robot. The results confirm the effectiveness of the proposed maneuver as well as the applicability of stability margins.

Keywords: Mobile robot, hybrid leg-wheel locomotion, step climbing, tipover stability, vehicle steerability, motion control.

1. Introduction

Surface discontinuities, such as steps, ramps, and gaps, are commonly found in indoors and urban environments. In wheeled and tracked vehicles, the size of crossable discontinuities is limited by the front wheel radius unless special wheel configurations [1][2], passive suspension arrangements [3][4][5], or specific control strategies [6] are employed. Alternatively, hybrid vehicles combine legs with wheels or tracks to improve mobility in the face of ground discontinuities [7].

Some hybrid mobile robots have wheels attached to the end of articulated legs [8] [9] [10][11]. These configurations are quite flexible but they require many actuators, which makes motion control complex and can increase energy consumption.

On the other hand, some wheeled or tracked robots have included legs with one degree of freedom (DOF) as climbing aids. One example is FUMA, whose 1-DOF link is used to hold sensors and also as a lever [12]. The addition of a flexible tail to the HELIOS carrier supports tracked locomotion for step climbing and descending [13]. Flipbot has two connected rigid links with 1-DOF that can be used as a backwards lever to climb stairs [14]. Furthermore, the Mantis differential drive wheeled robot uses a connected pair of forward levers for climbing single steps [15].

In some mobile manipulators, the onboard arm can act as a single leg that is pushed against the ground to support step climbing. For instance, the Sherpa rover manipulator has been specially designed to overcome tall obstacles by lifting up the vehicle [16]. Furthermore, terrace and step ascents have been performed with the Alacrane mobile robot in cooperation with a powerful hydraulic arm [17]. In this sense, the use of auxiliary

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