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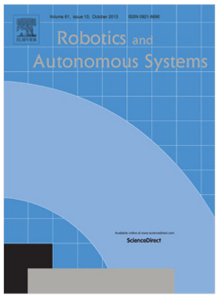

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Instantaneous Centre of Rotation Based Motion Control for Omnidirectional Mobile Robots with Sidewards Off-centred Wheels

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Abstract

AZIMUT-3 is a nonholonomic omnidirectional platform design using sidewards off-centred compliant wheels. This design makes it possible to experiment with the use of the chassis' instantaneous centre of rotation (ICR) for motion control. Research on ICR-based motion controllers has focused on handling structural singularities and misses a more general consideration of the chassis' kinematic and physical constraints like steering, velocity and acceleration constraints. This paper presents the design of an ICR-based motion controller for AZIMUT-3. Leveraging a new parametrization of the motion state space and the associated representation in $\mathbb{R}^3$ (collectively referred to as the H representation) and adapting a time scaling principle initially developed for manipulator trajectories, the designed motion controller is able to handle actuators coordination and their physical limits, as well as structural singularities. Results of tests done with the platform are presented, demonstrating the applicability of the proposed motion controller in efficiently handling these issues.

Keywords: instantaneous centre of rotation (ICR), nonholonomic omnidirectional robots, motion control, kinematics, wheeled robots

1. Introduction

Nowadays, a variety of robotic platforms are using omnidirectional locomotion mechanisms. Many use omnidirectional wheels like the Mecanum wheel [1] used on ARMAR-III [2] or the Segway RMP [3], which provide true omnidirectional motion but bring limitations in terms of odometry precision, vibrations and obstacle crossing [4]. Another common solution is to use steerable wheels, which provides accurate odometry and lower mechanical complexity [5]. Different types of steerable wheels have been designed, each with specific kinematic properties. The centred wheel is the simplest type and is used by HERMES [6] and Rollin' Justin [7, 8]. The caster wheel is the most common one, as used by Corsero [9], Dynamaid [10], Meka B1 [11] and Willow Garage PR2 [12], and enables pseudo-holonomic motion. Both have in common a steering axis lying within the rolling plane of the wheel. A third type is the sidewards off-centred steerable wheel, used by platforms based on Neobotix MPO-700 [13] (like Care-O-bot 3 [14, 15], DESIRE [16] and [17]) and Johnny-0 [18, 19], called AZIMUT wheel [20]. As illustrated by

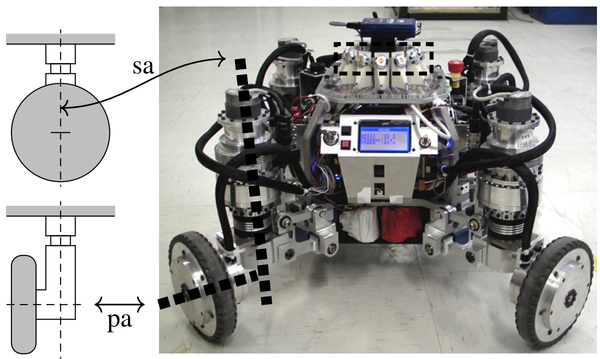

Figure 1: The AZIMUT-3 platform alongside an illustration of an AZIMUT wheel with its steering axis (sa) and propulsion axis (pa). Also visible are Optotrack wireless optical trackers (dashed rectangle) placed on top of the platform.

Fig. 1 and unlike the caster wheel, the steering axis of an AZIMUT wheel lies outside of its rolling plane. This creates a kinematic coupling between steering and propulsion, i.e., any steering motion needs an appropriate propulsion motion, even without chassis motion.

Employing steerable wheels leads however to nonholonomic platform designs, and the actuators then need to be carefully coordinated to guarantee safe and precise mo-

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