Path Following Control for Wheeled Mobile Robots in the Presence of Skidding and Slipping: Estimation-Based Backstepping Approach

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Abstract: Control problems for Wheeled Mobile Robots have attracted much attention in the past two decades, and many results have been proposed. Apparently, the control problems have been theoretically solved; however, most of these results are based on non-skidding and pure-rolling assumptions. In reality, the wheel's tires deform, and hence these two critical assumptions will fail to hold. Consequently, the stability and the performance of any controllers that were developed under the assumptions may no longer be valid. Some researchers have attempted to address these issues; and several results have been proposed in both kinematic and dynamic levels. At the kinematic level, the skidding perturbations were regarded as a general unknown term, suggesting robust control methodology deems to be the only solution. Thus many conservative control laws were proposed to address the problems. On the other hand, some dynamic solutions are also developed assuming all inertial and other critical parameters are accurately known. In reality, these parameters are usually unknown, and difficult to be estimated using system identification approach.

In this paper, we address the problem from another approach. We exploit a suite of suitable sensors and recently developed kinematic models to develop high-performance controller without constraining the control input unnecessarily. Here, we apply the concept to solve the path-following problem for the general Type (2,0), Type (1,1), Type (1,2) and Type (2,1) WMRs. Control problems are formulated and solved based on the maneuverability of each WMR. The controllers are developed based on backstepping methodology and perturbation estimates provided by the sensor suite. The proposed control scheme possesses the following salient features: 1) exponential convergence of path following lateral error with a well-behaved orientation error; 2) perturbations estimator; and 3) continuous control law without assuming constant or state vanishing perturbations. The control scheme has been validated by numerical simulation and the reported result confirms the controllers' effectiveness.

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