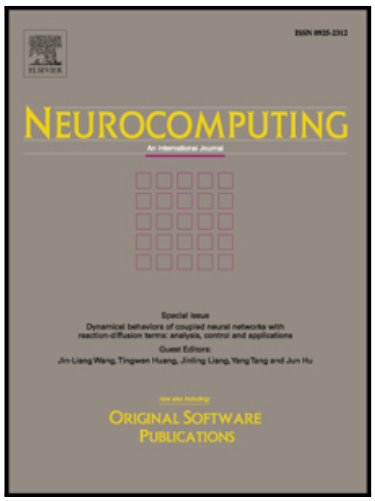

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PII: S0925-2312(17)31913-6
DOI: 10.1016/j.neucom.2017.12.051
Reference: NEUCOM 19185

To appear in: *Neurocomputing*

Received date: 10 September 2017
Revised date: 3 December 2017
Accepted date: 19 December 2017

Please cite this article as: Shu Li , Liang Ding , Haibo Gao , Chao Chen , Zhen Liu , Zongquan Deng , Adaptive Neural Network Tracking Control-Based Reinforcement Learning for Wheeled Mobile Robots with Skidding and Slipping, *Neurocomputing* (2017), doi: 10.1016/j.neucom.2017.12.051

Adaptive Neural Network Tracking Control-Based Reinforcement Learning for Wheeled Mobile Robots with Skidding and Slipping

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Abstract: To track the desired trajectories of the wheeled mobile robot (WMR) with time-varying forward direction, a reinforcement learning-based adaptive neural tracking algorithm is proposed for the nonlinear discrete-time (DT) dynamic system of the WMR with skidding and slipping. And, the typical model is transformed into an affine nonlinear DT system, the constraint of the coupling robot input torque is extended to pseudo dead zone (PDZ) control input. Three neural networks (NNs) are introduced as action NNs to approximate the unknown modeling item, the skidding and the slipping item and the PDZ item, whereas another NN is employed as critic NN to approximate the strategy utility function. Then, the critic and action NN adaptive laws are designed through the standard gradient-based adaptation method. The uniform ultimate boundedness (UUB) of all signals in the affine nonlinear DT WMR system can be ensured, while the tracking error converging to a small compact set by zero. Numerical simulations are conduced to validate the proposed method.

Keywords-Wheeled mobile robot, adaptive tracking control, reinforcement learning, neural network

1. Introduction

A robot is an automated device for performing human behavior or releasing mechanical functions. On the basis of the job space, robots can be classified into terrestrial, aerial and underwater robots. The WMR, which is a typical terrestrial mobile robot, has been widely used in social life, scientific research and engineering application. With the development of human society, operating environment and task requirements of a WMR tend to be complex, in terms of its function, organization and control algorithm design. Therefore, WMRs are faced with significant challenges, attracting the attention of a wide range of scholars [1]-[10]. However, the existing control algorithm is still not adequate to satisfy the increasingly complex task requirements, and an urgent need for new algorithms has also attracted the attention of scholars.

Considering a WMR as a typical nonlinear system, various tracking control algorithms have been proposed for it in the last few decades. A modified input-out linearization method was proposed in [11], a data-based tracking control of WMRs has been realized in [12]-[13], [14-15] presented a sliding-mode based tracking algorithms for two different types of WMRs. To overcome this problem, [16]-[18] presented several effective algorithms. Such as the extended state observer based nonlinear tracking and obstacle avoidance control in [16], generalized extended state observer-based robust tracking algorithm in [17], and Lyapunov redesign-based robust backstepping tracking control method in [18].

Corresponding to the traditional control algorithm, with the extensive application of a neural network (NN) [19]-[25], fuzzy logic system (FLS) [26]-[28] and fuzzy neural network (FNN) [29], adaptive intelligent control algorithm has been developed for a long-term usage. An adaptive fuzzy state observer controller was designed in [30] for the nonlinear discrete-time (DT) systems with unknown functions and bounded disturbances. To achieve a stable dynamic balance and tracking control, a linear dynamic compensator-based output feedback adaptive NN controller was designed in [31]. The