Chapter 20
Tracking Control of a Nonholonomic Mobile Robot Using Neural Network

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ABSTRACT

The goal of this chapter is to enable a nonholonomic mobile robot to track a specified trajectory with minimum tracking error. Towards that end, an adaptive P controller is designed whose gain parameters are tuned by using two feed-forward neural networks. Back-propagation algorithm is chosen for online learning process and posture-tracking errors are considered as error values for adjusting weights of neural networks. The tracking performance of the controller is illustrated for different trajectories with computer simulation using Matlab/Simulink. In addition, open-loop response of an experimental mobile robot is investigated for these different trajectories. Finally, the performance of the proposed controller is compared to a standard PID controller. The simulation results show that "adaptive P controller using neural networks" has superior tracking performance at adapting large disturbances for the mobile robot.

1. INTRODUCTION

The inspiration of technology in the new mechatronics era is the design of human-oriented machines that implies intelligent and cooperative coexistence beyond time and physical constraints (Habib, 2007). So mechatronics and robotics constitute one of the keys to human social and economic development (Tzafestas, 2014a; Tzafestas, 2014b). The benefits of using autonomous and intelligent mobile robots as a mechatronic system in medical, assistive and service applications are numerous and their positive impact in modern society is steadily increasing, because these robots can perform various actions wisely and autonomously. A mobile robot is suitable for many types of applications that require high autono-

DOI: 10.4018/978-1-4666-7387-8.ch020

mous in a wide variety of fields, just like in the factory and industry, in the society (rescue, guidance, safety, hospital services, cleaning, entertainment and other services). So the interest of mobile robots in scientific studies has been increasing rapidly due to the width of the potential of applications.

If we consider the most important ability of mobile robots is autonomous mobility, it has understood that the performance of tracking prescribed trajectories is very important. The tracking control approaches for the mobile robots are mainly divided into six types (Ye, 2008):

1. State feedback linearization;
2. Sliding-mode control;
3. Backstepping control;
4. Computed torque;
5. Adaptive control;
6. İntelligent control.

Different control systems have been used in previous works about wheeled mobile robots. Haddad et al. (2007) have presented a random-profile approach to treat the optimal free-trajectory planning problem with various forms of optimization criteria involving travel time, efforts and power for nonholonomic wheeled mobile robots subjected to move in a constrained workspace. Also Huang (2009) has applied the potential field method in a dynamic environment where the target and the obstacles are moving. The method was applied for both path and speed planning, or the velocity planning, for a mobile robot to make the robot track the moving target while avoiding moving obstacles.

Martins et al. (2008) have proposed an adaptive controller to guide tracking a trajectory of an unicycle wheeled mobile robot. The parameters of the robot dynamics were updated on-line, because these parameters can vary, such as load transportation. Chen et al. (2009) have designed an adaptive sliding-mode dynamic controller for wheeled mobile robots to implement the trajectory-tracking mission by making the real velocity of the wheeled mobile robot reach the desired velocity command, although the system uncertainties and disturbances. Klancar and Skrjanc (2007) have applied a model-predictive trajectory-tracking control to a wheeled mobile robot. Linearized tracking-error dynamics was used to predict future system behaviour and a control law was derived from a quadratic cost function penalizing the system tracking error and the control effort.

Defoort et al. (2009) have proposed a decentralized motion planner for a team of nonholonomic mobile robots. The motion planning scheme consisted of decentralized receding horizon planners that reside on each vehicle to achieve coordination among flocking agents. Tsai and Song (2009) have designed a robust visual tracking control design for a nonholonomic mobile robot. The control design was equipped with a camera and made the mobile robot to keep track of a dynamic moving target in the camera's field-of-view. They proposed a control system consisting of a visual tracking controller and a visual state estimator. Also Tsai et al. (2009) have proposed a design of a robust visual tracking control system, which consists of a visual tracking controller and a visual state estimator to facilitate human-robot interaction of a mobile robot.

Yang and Kim (1999) have proposed a novel sliding mode control law for robust tracking control of nonholonomic wheeled mobile robots. Normey-Rico et al. (2001) have proposed PID control method as a simple and effective solution for the path tracking problem of a mobile robot. Sugisaka and Hazry (2007) have designed a proportional controller whose parameters for each wheel were decided by confirmation of the minimal root mean square error (RMSE) of deviation in wheel rotations for each wheel.

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