Dynamics of Continuous, Discrete and Impulsive Systems
Series **B:** *Applications & Algorithms* **10 (2003)** 695-708

REAL-TIME ROBOT MOTION PLANNING AND TRACKING CONTROL USING A NEURAL DYNAMICS BASED APPROACH

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Abstract. In this paper, a novel neural dynamics based approach is proposed for real-time motion planning and tracking control of a mobile robot in an arbitrarily changing environment. The dynamic environment is represented by a neural activity landscape of a neural network, where each neuron in the topologically organized neural network is characterized by a shunting equation that is derived from Hodgkin and Huxley's (1952) biological membrane equation. The collision-free robot motion is generated in real-time through the activity landscape without any explicit searching procedures and without any prior knowledge of the dynamic environment. The real-time tracking control of the robot to follow the planned dynamic motion path is designed using shunting equations as well. The effectiveness and efficiency of the proposed approach are demonstrated through simulation studies. Simulation in several computer-synthesized virtual environments further demonstrates the advantages of the proposed approach with encouraging experimental results.

Keywords: Neural dynamics, path planning, tracking control, real-time, Lyapunov stability, mobile robots, robot manipulators

1 Introduction

Real-time path planning and tracking control of robotic systems are fundamentally important but very difficult issues in robotics, particularly in a nonstationary environment. Many previous works deal with the robot path planning and the tracking control problems separately [2, 3, 5, 6, 9–11, 14, 16, 17, 20, 26]. There are many studies on path planning of robots using various approaches [3–6, 9–14, 16, 17, 26]. However, most of the previous models deal with static environment only and are computationally complicated. Many path planning models use global methods to search the possible paths in the free space (e.g., [1, 4, 9]). Ong and Gilbert [17] proposed a new model for path planning with penetration growth distance, which searches over collision paths instead of the free space. However, these models deal with static environment only and are computationally complicated when in a complex environment (e.g., [14, 17, 26]).

Several neural network models were proposed to generate real-time trajectories through learning (e.g., [3, 12, 16, 21, 25]). Ritter et al. [21] proposed