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Chapter IV

A Biologically Inspired Neural Network Approach to Real-Time Map Building and Path Planning

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ABSTRACT

A novel biologically inspired neural network approach is proposed for real-time simultaneous map building and path planning with limited sensor information in a non-stationary environment. The dynamics of each neuron is characterized by a shunting equation with both excitatory and inhibitory connections. There are only local connections in the proposed neural network. The map of the environment is built during the real-time robot navigation with its sensor information that is limited to a short range. The real-time robot path is generated through the dynamic activity landscape of the neural network. The effectiveness and the efficiency are demonstrated by simulation studies.

INTRODUCTION

Real-time path planning with collision free in a non-stationary environment is a very important issue in robotics. There are a lot of studies on the path planning for robots using various approaches. Most of the previous models use global methods to search the possible paths in the workspace (e.g., Lozano-Perez, 1983; Zelinsky, 1994; Al-Sultan & Aliyu, 1996; Li & Bui, 1998). Ong and Gilbert (1998) proposed a new searching-based model for path planning with penetration growth distance, which searches over collision paths instead of the free workspace. Most searching-based models can deal with static environment only and are computationally complicated when the environment is complex. Some of the early models deal with static environment only, and may suffer from undesired local minima (e.g., Ilari & Torras, 1990; Zelinsky, 1994; Glasius et al., 1994). Some previous robot motion planning models require the prior information of the non-stationary environment, including the varying target and obstacles. For example, Chang and Song (1997) proposed a virtual force guidance model for dynamic motion planning of a mobile robot in a predictable environment, where an artificial neural network is used to predict the future environment through a relative-error-back-propagation learning.

Several neural network models were proposed to generate real-time trajectory through learning (e.g., Li & Ogmen, 1994; Beom & Cho, 1995; Glasius et al., 1994; 1995; Zalama, Gaudiano & Lopez Coronado, 1995; Chang & Song, 1997; Gaudiano et al., 1996; Yang, 1999; Yang & Meng, 2000a, 2000b, 2001). The learning based approaches suffer from extra computational cost because of the learning procedures. In addition, the planned robot motion using learning based approaches is not optimal, especially during the initial learning phase of the neural network. For example, Zalama et al. (1995) proposed a neural network model for the navigation of a mobile robot, which can generate dynamical trajectory with obstacle avoidance through unsupervised learning.

Glasius et al. (1995) proposed a neural network model for real-time trajectory formation with collision free in a non-stationary environment. However, this model suffers from slow dynamics and cannot perform properly in a fast changing environment. Inspired by Hodgkin and Huxley's (1952) membrane equation and the later developed Grossberg's (1988) shunting model, Yang and Meng (2000a) proposed a neural network approach to dynamical trajectory generation with collision free in an arbitrarily changing environment. These models are capable of planning a real-time optimal path in non-stationary situations without any learning process. But the planned paths in Glasius et al. (1995) and Yang and Meng (2000a) do not take into account the clearance from obstacles, which is demanded in many situations. By introducing inhibitory lateral connections in the neural network, Yang and Meng (2000b) proposed a new model for path planning with safety consideration, which is capable of generating a "comfortable" path for a mobile robot, without suffering either the "too close" (narrow safety margin) or the "too far" (waste) problems. However, the models in Ilari and Torras (1990), Zelinsky (1994), Zalama et al. (1995), Glasius et al. (1995) and Yang and Meng (2000a, 2000b) assume that the workspace is known, which is not practically feasible in many applications.

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