

Chapter 57

An Adaptive Path Planning Based on Improved Fuzzy Neural Network for Multi- Robot Systems

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ABSTRACT

The fuzzy neural network (FNN) is the combination of fuzzy theory with neural network, which has advantages of validity and adaptability in robot path planning. However, the path planning based on the FNN is not optimal because of the limitations of the subjective experience and motion mutation and the dead-zone. In this paper, FNN is improved by using A graph search algorithm to guarantee an optimal path, providing the rationality and the feasibility, in which the grid map is divided into two stages, including the A* algorithm in the first stage and FNN in the second stage. In addition, a neural network based on adaptive control strategy is introduced to compensate the sensor failure and ensures the stability, which is caused by the loss of data and information uncertainty. The simulation results show that the approach is with effective performance in the robot path planning.*

INTRODUCTION

Intelligent mobile robot is an integrated system that can achieve functions of environments apperceiving, dynamic decision-making, motion control and path planning (Fikes, Hart, & Nilsson, 1972; Holland, 1975). It has been widely used in the field of dangerous environments, e.g., planetary exploration, military reconnaissance, medical service, earthquake rescue, deep sea and nuclear industry because of its high flexibility, intelligence and environmental adaptability. The collision detection is the important problem should be concerned in the multi-robot systems (Asama, Matsumoto, & Ishida, 1989).

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Fuzzy neural network (FNN) is a local approximation network that combines the knowledge structure of fuzzy logic reasoning with the self-learning ability of neural network (Liu, 2011). The traditional neural network is provided with fuzzy input signals and fuzzy weights, which has been widely applied. A* algorithm is the best first search method in the heuristic search algorithm proposed by the Nilsson in 1980, which is a global planning algorithm based on area and searching optimum paths between nodes based on valuation function in figure (Brooks, 1986). A* algorithm has been applied in the fields of artificial intelligence and is used for path searching because of its high efficiency and fast speed (Farooq, Arif, Amar, & Tahir, 2010). The heuristic function $h(n)$ in A* guarantees the minimum cost evaluation value from any node n to the target node, and continuously provides the “best” direction to search by using the heuristic information in the evaluation function. Based on the different terrain, the different heuristic function is selected to improve the efficiency.

Normally, robots often don't walk along the feasible paths in the A* algorithm planning, but the edge and corner of the obstacles. The path planning using A* is very easy to collide with obstacles and lead to the failure in a real environment. The path planning using FNN is a relatively smooth path, but with the shortcoming of that the path is not the shortest, resulting in that the robot will be in the motion mutation and the dead-zone formation (Hofner, & Schmidt, 1995). The combination of the two algorithms is proposed to the improved FNN, providing smooth feasible optimal path for the robots. The grid map is divided into two stages by the two-stage fusion algorithm in the path planning (Azouaoui, Ouadah, Mansour, & Semani, 2011). The first stage is only an experience setting of the probability, and the obstacles and the feasible regions are distinguished in detail in the second stage. The number of grids in the first stage can be divided into the grids in the second stage, and the grids in the first stage is composed of $N \times N$ in the second stage. Therefore, the shortest path is briefly planned by A* algorithm in the first stage, and then a more reliable smooth path is planned by FNN in the second stage.

The ultimate goal of robot path planning is to find a smooth feasible shortest path and ensure that the robot can reach the target point. The robot path planner designed should follow this principle (Pham, & Sukkar, 1995). The robot can find the shortest path with obstacles in the map by A* algorithm, while a relatively smooth path is planned by FNN. The improved FNN algorithm is combined with FNN and A* algorithm, which a smooth feasible optimal path can be found for robot by two-stage path planner designed, which A* algorithm is run to plan the shortest path in the first stage, and then FNN is run to plan a smoother path in the second stage (Dong, & Li, 2009). In order to solve the instability of the system caused by sensor failure, the neural network robust adaptive control method is proposed to track and control the nonholonomic mobile robot, which the control system has good dynamic and static performance by using neural network to approximate the nonlinear part and the uncertainties and disturbances being eliminated by robust control in the system (Yao, Lin, & Xie, 2010; Tsai, Huang, & Chan, 2011). The neural network can correctly extract the model parameters of the controlled object because of its self-learning and trained, and improve the ability of controller because of its strong antijamming and fault-tolerant. Finally, the simulation results show that two-stage fusion algorithm has higher efficiency, shorter path length and less time in robot path planning, which achieve the expected results that the adaptability of the mobile robot is realized. And the stability of system is ensured by using robust adaptive control strategy based on neural network, and the dynamic performance of the system is improved, which the better robustness and controlling are achieved.

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