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Evolution of Neural Controllers for Exploration of Dynamic Environments

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Abstract

Environment exploration of dynamic unknown environments is an attractive research issue. In this paper, we propose an evolutionary based method to deal with this issue. We evolved a neural controller that uses the laser data and information of unexplored environment to generate the robot best action. The map of the environment is generated by the robot in a form of a binary matrix. The explored are is used as fitness function of the genetic algorithm. The experimental results show a good performance of the proposed method for exploration of unknown dynamic environments.

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Keywords: nvironment exploration, neural network, genetic algorithm, intelligent robot.

1. Introduction

Robot environment exploration, which is the total area covered by the robot sensors, has many applications such as monitoring, search and rescue operations inside buildings.

A significant amount of research has been done in mobile robot environment exploration. In most of previous works, the frontier-based exploration algorithm ([1], [2]), which are the regions on the boundary between open space and unexplored environment, is utilized. In [2], the method was tested in exploring real-

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world office environment using a real mobile robot. In [3], a mobile robot autonomous exploration of unknown indoor environment and building a semantic map is presented. The map developed by the robot contains high-level information which are similar to those extracted by humans.

Recently multi-robot coordination using probabilistic approach for environment exploration is proposed ([4], [5]). In [4], the authors introduced the concept of the utility of the target points, which is given by the size of the unexplored area that a robot can cover with its sensors upon reaching a target position. In [5], the authors incorporated multiple objective utility functions, which improved the exploration of each robot and the group of robots as a whole. The introduced concept has a great influence on the direction of areas of primary exploration. In addition, the human experts specify the preferred and avoidance regions at intervals during run-time.

In this paper, we propose an evolutionary based method for environment exploration. In our method, we evolve the weight connections of the neural controller that map the sensory data to robot action. The robot utilizes the frontier based exploration and Laser Range Finder (LRF) data to select the best action. In addition to environment exploration, the robot learns the obstacle free navigation. The performance of evolved neural controllers is tested in dynamic environments with obstacles of different sizes placed in random locations. In addition, the robot created an internal map of the environment, which helps the robot to move toward the unexplored areas. Experiments using iRobot create show a good performance of evolved exploration strategy in real life environments.

The paper is organized as follows. The mobile robot is explained in Section II. The environment used in the simulations is described Section III. Neural controller and Evolutionary algorithms are presented in Section IV and Section V, respectively. The simulations and experimental results are included in Section VI. Finally, the concluding remarks end the paper.

2. Robot

In the exploration task presented in this paper, we use the iRobot create (Fig. 1), a programmable robot based on Roomba vacuum-cleaning robot. It’s a disc type mobile robot with a 17cm radius. This is a differential drive robot with two powered wheels. Each wheel may be controlled independently with a maximum speed of 0.5m/s. In our implementation, we consider the LRF as the sensor for robot navigation and environment exploration. In our implementation, the LRF has a field of view of 180 degrees and return 181 distance readings (one per degree). The maximum error is +/-3 cm per 4 meters. The robot sensors are connected with a laptop computer running Matlab.

Fig.1. iRobot Create.

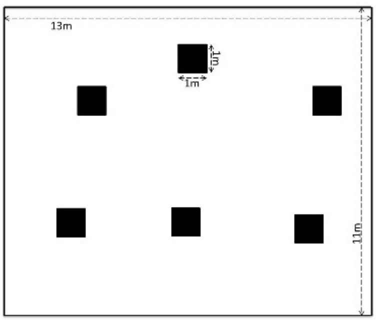

Fig.2. Simulated environment