ICIEA 2022

16 - 19 Dec 22

Chengdu, China

ICIEA22-000330

Q-learning-based Collision-free Path Planning for Mobile Robot in Unknown Environment

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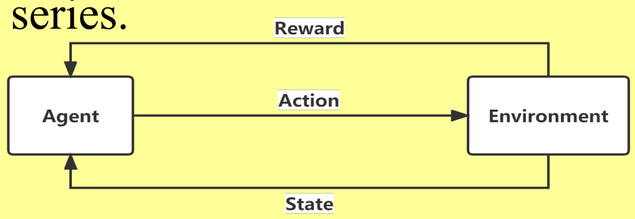
1.Introduction

With the complexity of application scenarios, higher performance requirements are imposed for the autonomous navigation ability of mobile robots. This paper proposes a Q-learning path planning method to achieve collision-free motion for the mobile robot in an unknown environment. An improved Q-learning algorithm is firstly designed by using unfixed reward function, expanded action space, and dynamic parameters in order to get an optimized and collision-free path. The convergence is reinforced by combining the gravity function in the artificial potential field algorithm and using the deep neural network instead of the Q-table.

2.Methodology

2.1 Q-learning Algorithm

The essence of an agent's trial-and-error Q-learning is to obtain an optimal strategy and get the maximum reward. When the robot obtains the max Q-Value in each step, the optimal action can be selected in each state and an optimal path is find by connecting all the actions in series.

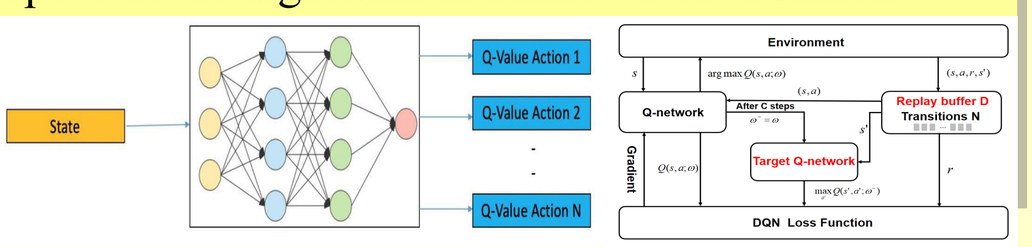


2.2 Gravity function in Q-Value updating

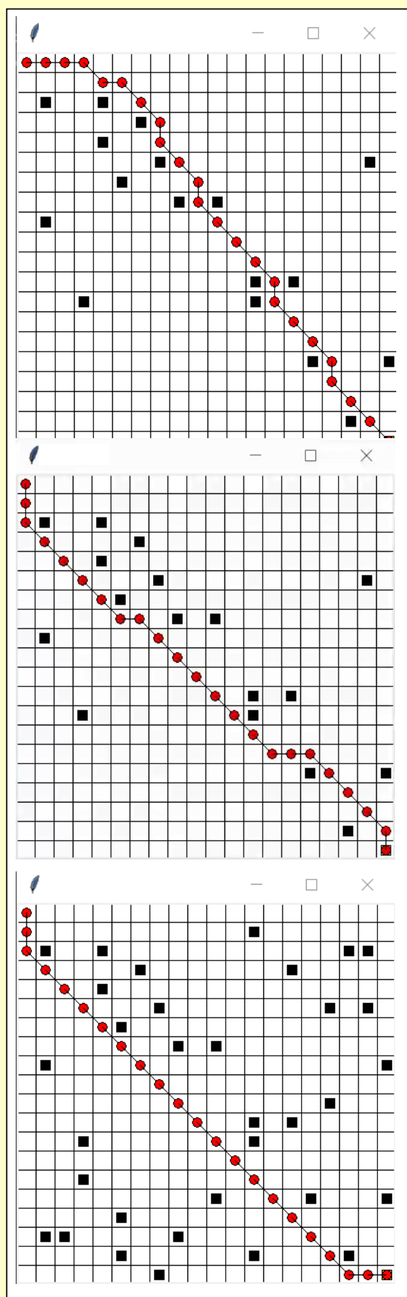
Artificial potential field method guides the path planning of mobile robot by assuming it moves in virtual force field. The gravity value function is introduced into Q-value updating step, establishing the "sense of direction" of the mobile robot under the condition of an unknown map environment.

2.3 Combing Deep Neural Network

Q-table is replaced by deep neural network to solve the problem of dimension explosion in complex environment. Based on experience replay and fixed target network to solve problems of experience waste and network instability. Accelerate convergence speed of the algorithm in unknown environment.



3.Results and analysis



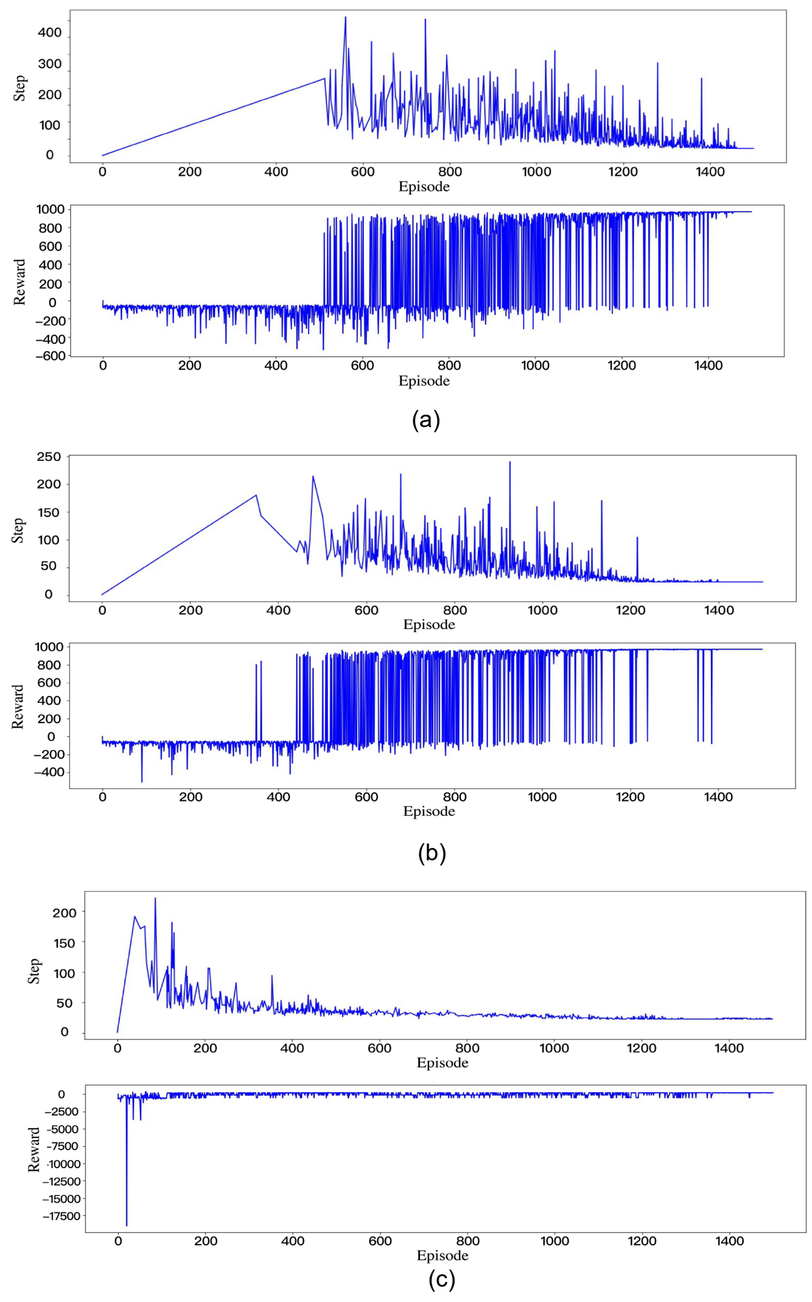


Fig1.Simulation experiment path planning results
(a). Traditional Q-learning
(b). Q-learning with gravity function
(c).Deep Q-learning

Fig2. Relationship curve between learning episodes and robot execution steps and reward values
(a). Traditional Q-learning
(b). Q-learning with gravity function
(c).Deep Q-learning

After using the gravity function, the total path angle ,the number of steps and the convergence speed is optimized. Using Deep Neural Network in Q-learning algorithm for mobile robot path planning can significantly reduce the convergence episodes of training.

4.Conclusions

1.Q-learning path planning of mobile robot strengthen the auto decision-making ability in unknown environment.
2.Gravitational potential field is applied to the updating step of Q-learning algorithm to avoid the blind exploration of mobile robots, getting fewer convergent episodes.
3. Deep neural network is used to replace, which improves the result of path planning by using its two core elements of experience replay and the fixed target network.