Research on Global Path Planning of Artificial Intelligence Robot Based on Improved Ant Colony Algorithm

Hairu Zhao¹*, Hui Zhou¹ and Guiqin Yang¹
¹Yuxi Normal University, Yuxi, China, 653100
*Corresponding author e-mail: zhr@yxnu.edu.cn

Abstract. With the rapid development of science and technology and the improvement of people's living standards and enjoyment consciousness, robots have come into people's field of vision more and more. People's use of robots in production and life has greatly increased. As an important function of the normal use of the robot and evaluating the quality level of the robot, the careful design and optimization of the path planning is the most important. This study discusses the basic situation of robot global path planning, the application, advantages and improvement measures of ant colony algorithm in robot path planning, which provides help for the further development and popularization of robot.

Keywords: Robot, Artificial Intelligence, Ant Colony Algorithm

1. Global path planning of robot

1.1. Basic definition of path planning
Robot path planning refers to the mobile robot according to one or some performance indicators. Find an optimal or near-optimal path from the initial state to the target state and avoiding obstacles in the motion space¹.

Path planning is divided into 1). Global path planning: It is a macro planning, which mainly provides the core motion points for the robot in motion to ensure that the robot reaches the destination safely, but the global path planning may not generate a trajectory, but some discrete points. 2). Local path planning: In order to achieve a more reasonable route of the robot, local path planning is also needed. It can restrain the speed and acceleration of the robot.

To put it simply, a robot needs to know how to locate itself in the environment, or find its own location, draw a map of the environment in real time, avoid obstacles that may appear at any time, and control its own motor to change speed or direction. make a plan to solve the task, and so on. Therefore, the really important part of robot design is the ability to plan the path from one location to another when the environmental map is known. When a robot must move from a starting position to a target position in order to complete a task, it must make a path plan for how to move in the surrounding environment. In robotics papers, path planning is usually described as a map with a starting position and a target location. This is a typical problem in mobile robot technology, which is often called path planning².
1.2. Evaluation criteria and characteristics of path planning

The criteria for judging path planning are usually based on the completeness, probability completeness, optimality and asymptotic optimality of the path, where:

(1) completeness: It means that if there is a path solution between the target point and the start point, then the solution must be obtained, and if the solution is not obtained, then there must be no solution.

(2) probability completeness: It means that if there is a path solution between the target point and the start point, as long as the planning or search time is long enough, we will be able to ensure that a path solution can be found.

(3) optimality: It means that the planned path is the best in a certain evaluation index.

(4) Asymptotic optimality: It means that the path obtained after finite programming iterations is close to the optimal suboptimal path, and it is closer to the optimal path after each iteration, which is a process of gradual convergence.

An excellent robot path planning system should have the following characteristics:

(1). Path planning should be feasible on practical robots. If path planning requires a robot to turn at a very small angle, but the robot cannot turn at a precise angle like a car, then this path planning should not be allowed.

(2). Path planning should be as close to the optimal solution as possible. Path planning that allows a robot to reach a target point from a starting point.

(3) path planning should avoid collision with walls.

2. Application of ant colony algorithm in path planning

2.1. The basic principle of ant colony algorithm

The basic idea of ant colony algorithm comes from the shortest path principle of ants foraging in nature\(^3\).

The researchers tried to restore the scene of ants looking for food. Imagine an ant finding food and it needs to take it back to the nest. For this ant, it obviously doesn't know how to go. In that case, it is possible for this ant to choose a random route. This route is likely to be a long way. But the ants left a mark, the pheromone, along the way. If the ant continues to carry food constantly, or if there are many other ants carrying it together. They always take the faster round trip route when they are lucky. The better the path the ants choose, the rounder trips they make at the same time, leaving more pheromones on the road. As a result, ants will always find that there are some paths with thicker pheromones, and these paths are better routes. As a result, the ants are more likely to shift to a path with a higher concentration of pheromones. The ants keep repeating this process, and eventually they can always find a definite route, and this route is the best path that the ants find.
2.2. The basic process of ant colony algorithm.

The basic ant colony has two basic processes:\(^4\):

2.2.1. status transfer

The residual information should be updated when every ant has taken one step or finished traversing all n cities.

2.2.2. pheromone update

There are three related models, including ant week model, ant quantity model and ant density model. The differences between these models are: 1). The ant cycle model uses global information, that is, ants update pheromones on all paths; 2). The ant quantity and ant density model use local information.

2.3. Simple application of ant colony algorithm

In general, ant colony algorithm, prime algorithm and Kruskal algorithm are three commonly used algorithms when finding the shortest path. Among them, this kind of algorithm is the optimal algorithm. First of all, traditional shortest path algorithms such as Prime, Kruskal have a limitation that they can only plan static paths, but the path planning needed in real life is often dynamic. For example, in the earthquake rescue, some roads may collapse and cannot travel. For example, in real-time traffic path planning, traffic jams in some places can be regarded as impassable paths. At this time, the traditional shortest path algorithms such as Prime can not adapt to the dynamic change of the path.

Secondly, with regard to the convergence speed, the algorithm has a fast searching ability all over the world in the starting stage of population evolution, while the searching speed is slower in the next stage. On the other hand, the ant colony algorithm is slow in the lack of information in the early stage, and converges quickly in the later stage. Prime algorithm and Kruskal algorithm are heuristic algorithms, they are effective for specific problems in specific areas, but once the cross-domain problems are solved, the effect decreases sharply.

Therefore, they are only to solve a certain kind of problem, and these problems already have these algorithms, so it is not necessary to use ant colony algorithm. However, this kind of algorithm has ability to be used to ewsolve some problems that have not yet found an effective algorithm. And ant colony algorithm has more obvious cross-domain ability and can have beautiful results in many fields.

3. Defects and improvement measures of ant colony algorithm

Ant colony algorithm has several defects in global path planning:

Figure 2. Basic structure of ant colony algorithm.
3.1. The Slow speed of convergence
Although the random selection of ant colony algorithm can explore a larger task space, it is helpful to acquire the potential global optimal solution. But, it takes a long time to play the role of positive feedback.

3.2. Local optimal problem
This kind of algorithm has the features of positive feedback, the pheromones in the initial environment are exactly the same, and the ants almost complete the construction of the solution in a random way. Although the positive feedback makes the algorithm have a better convergence speed, if the better solution obtained by the algorithm is the suboptimal solution, then the positive feedback will make the suboptimal solution occupy the advantage quickly, make the algorithm fall into the local optimal, and it is difficult to jump out of the local optimal[5].

3.3. Optimize the ability problem
There are lots of parameters in this kind of algorithm and have certain relevance. The parameter selection of ant colony algorithm depends more on experience and trial and error, and inappropriate initial parameters will weaken the ability of optimization of the algorithm.

3.4. There is a contradiction between population diversity and convergence rate
So positive feedback reduces the diversity of population and is not conducive to increase the global optimization ability of this algorithm. Therefore, this kind of algorithm is able to be improved from the following three aspects[6]:

3.4.1. Structural aspects
The structure of this kind of algorithm is improved so as to effectively promote the optimization ability of the algorithm, accelerate the convergence speed and avoid premature convergence. Generally speaking, increasing the use of the optimal solution in the iterative process and weakening the influence of the worst solution can significantly improve the convergence of the algorithm. For example, introducing pheromone restriction measures into this type of algorithm and combining it with the method of adaptive pheromone volatilization coefficient can solve the stagnation phenomenon in ant colony algorithm to some extent. This also increases the searching ability of the algorithm.

3.4.2. Optimize initialization method
Ant colony algorithm initializes the values of pheromones uniformly. This method has the blindness of search at the first stage of this algorithm, which makes deadlock in path planning, affecting the convergence speed and optimization ability of this algorithm. Therefore, uneven initialization can improve these problems. For example, the pheromone initialization is carried out according to the characteristics of the task and the optimal path, or the initial path obtained by other optimization algorithms is used as a reference for the initial value of the pheromone.

3.4.3. Guidelines for improving pheromone updates
Pheromone update includes global pheromone update and local pheromone update. Improvements to the pheromone update criteria usually limit the movement step to a single grid. This criterion leads to long path and lack of smoothness in global planning. After improving it, such as using multi-step ant colony algorithm, it can effectively improve the smoothness of the path and reduce the length of the path.

4. Conclusion
Robot path planning belongs to one of the important links in the process of robot research and development. Because ant colony algorithm has more obvious cross-domain ability, it is chosen as one
of the effective algorithms for robot global path planning. However, the old ant colony algorithm has some problems in completing the global path planning of artificial intelligence robot, easy to fall into the local optimal solution, including slow convergence speed and so on. Through discussion, the optimization of this type of algorithm from three aspects: structure, initialization method and pheromone update criterion can effectively improve the quality of robot global path planning.

Acknowledgments
1. Construction Plan of Key Laboratory of Institutions of Higher Education in Yunnan Province;
2. University Joint Youth Project of Yunnan Provincial Department of Science and Technology: Localization technology and Path planning of mobile robot, 2017FH001-102;
3. Youth Project of Yunnan Science and Technology Department: Research on blind Equalization Algorithm of Single Carrier Frequency Domain based on optimal multi - base LDPC Code in wireless Communication, 2017FD162;
4. College students Innovation and Entrepreneurship training Project of Yuxi Normal University: Research on the Flipped classroom Teaching Model of automatic Control Theory.

References
[1] Zhang Xiaoli, Yang Yali, Xie Yongcheng; Application of Improved Ant Colony Algorithm in Robot Path Planning [J]; Computer Engineering and Applications; 2020.
[2] Liu Jianhua, Yang Jianguo, Liu Huaping, Geng Peng, Gao Meng; Robot Global Path Planning Based on Ant Colony Optimization with Artificial Potential Field [J]; Transactions of the Chinese Society for Agricultural Machinery; 2015.
[3] Zhu Yan, Liu Xiaoming, Liu Sheng, Yuan Wangfeng; Research for robot path planning problem based on improved Ant Colony System (ACS) algorithm [J]. Computer Engineering and Applications; 2018.
[4] Kang Bing, Liu Xihui, Yang Fu; Path planning of searching robot based on improved and colony algorithm [J]; Journal of Jilin University(Engineering and Technology Edition); 2014.
[5] Feng Shengfei, Lei Qi, Wu Wenlie, Song Yuchuan; Mobile robot path planning based on adaptive ant colony algorithm [J]; Computer Engineering and Applications; 2019.
[6] Zhang Songcan, Pu Jiexin, Si Yanna, Sun Lifan; Survey on Application of Ant Colony Algorithm in Path Planning of Mobile Robot [J]; Computer Engineering and Applications; 2020.