Robot Path Planning Method Based on Genetic Algorithm

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Abstract. Intelligent mobile robots are robots that can automatically complete driving tasks without human intervention. Route planning is the main problem in robotics research. The goal is to find the lowest cost, conflict-free route from the known starting point of the obstacle route to the known end point. Genetic algorithms are based on the natural selection of populations and the random, repetitive and evolutionary processes of genetics. This is a very effective algorithm in the field of route planning research. In this article, I will first explain the design principles of mobile robots. After comparing the advantages and disadvantages of various routing methods, a genetic algorithm was chosen to solve the routing problem of mobile robots. Then, through detailed research on genetic algorithm, a solution to robot path programming based on genetic algorithm in static and dynamic environments is proposed. In the design of genetic operons, standardization, insertion and deletion of operons have been added to make up for the lack of basic operons. At the same time, the genetic algorithm is optimized through adaptive mutation and crossover rate. You can improve the algorithm by adding new operators and adaptive methods to solve the problem that the target point cannot be reached due to the local minima in the evolution process. Finally, in three static environments with different levels of complexity, simulation experiments are carried out and the simulation results are analyzed. The influence of different fitness parameters on the path planning results is discussed, and the dynamic path planning simulation is carried out. Through comparison with other methods, it can be found that in the same environment, the path planning method based on genetic algorithm saves at least 5% time than Dijkstra algorithm in search time.

Keywords: Genetic Algorithm, Robot, Path Planning Method, Di Jkstra Algorithm

1. Introduction

1.1. Background and Significance
With the rapid development of science and technology, the application fields of robots are gradually expanding [1]. Robots are not limited to simple operations. Many intelligent mobile robots are also widely used in military, civil and scientific research, including aerospace, navy, military, construction, medical, service, agriculture and forestry, office automation, disaster relief, robotics and other fields...
Intelligent mobile robots (such as nursing robots) need to have advanced functions such as perception, programming and control. If the environmental information is partially or completely unknown, they can gather knowledge from the environment, build symbolic global models for the environment, and use these models to design and perform high-level tasks. Moving automatically to the destination and avoiding obstacles in various environments is one of the most basic and important functions of a mobile robot, and is the foundation of all other applications. Therefore, route planning has become a key issue in the field of mobile robot control [3]. The key issue is also one of the key technologies of robots.

Route design is a necessary and important part of mobile robot navigation technology. This is the safety guarantee for the mobile robot to complete its task, and it is an important sign of the mobile robot's intelligence level. In-depth research on route planning algorithms can continuously improve the navigation performance and intelligence of portable robots, and promote the further development of portable robots [4-5].

### 1.2. Related Work

In the 1950s and 1960s, some computer scientists developed their own so-called "artificial evolutionary systems." The starting point is to develop evolutionary thinking into optimization tools for many engineering problems. The prototype of genetic algorithm. In the early 1960s, when I. Rechenberg and HP Schwefel of the Berlin Institute of Technology conducted wind tunnel experiments, it was difficult to optimize the parameters representing the shape of objects in the design by conventional methods, so biological mutations were made and the idea of was adopted [6]. Change parameter values randomly to get the best results. Then, we carefully studied this method and created another branch of Evolutionary Informatics (ES). Currently, ES and GA have been integrated. In addition, in the 1960s, L.J, Fogel and others proposed evolutionary design in the design of finite state automation, borrowing the idea of evolution to develop the FSM team to obtain a better FSM. However, over time, this method is no longer applicable.

### 1.3. Main Content

This article focuses on the application of genetic algorithm in mobile robot route design. First, analyze and study various theories and algorithms currently used in mobile robot route planning, and compare their advantages and disadvantages. The method of using genetic algorithm for mobile robot path planning in dynamic and static environment is studied in detail. The focus of the research is to solve the route planning problem. First consider finding a feasible route, and then consider the route result, which is divided into two parts: route planning and route optimization. Path planning is divided into static path planning and dynamic path planning according to the environment. The dynamic environment is formed by introducing obstacles based on the static environment, that is, in the global design, the environment will change, for example, the programmed route will appear in the "New Obstacle" row. The main task of path optimization is to ensure the best combination of path length, simplicity (small number of turning points and unnecessary paths) and smoothness (corner smoothness). With the method in this document, the time taken by the robot to move the path is reduced by 5% compared to usual.

### 2. Research Method of Robot Path Planning Method Based on Genetic Algorithm

#### 2.1. Navigation Method of Mobile Robot

The first problem that robot navigation technology solves is which navigation method to use, that is, which sensor system is used to recognize the external environment and guide the next action of the robot. Common robot navigation methods include electromagnetic navigation, light reflection navigation, environment map matching navigation, road sign navigation, optical navigation, sensor data navigation and satellite navigation [7].
In addition, there are robot navigation methods based on sensor data. Robots are usually equipped with non-optical sensors such as ultrasonic sensors, infrared sensors and contact sensors. Use these sensors to navigate the robot. For example, if the robot is in a dark environment, the visual navigation method will fail. In this case, other sensors (such as ultrasonic sensors) can be used for navigation. The use of ultrasonic sensors is not affected by light, and the system composed of ultrasonic sensors has many advantages, such as simple structure, small size and high cost performance, so in the field of robotics, especially in automatic mobile robots. widely used. In addition to the conventional navigation methods mentioned above, there are odor navigation, voice navigation and so on. However, in practical applications, different navigation methods are usually combined to obtain the best navigation effect. For example, some researchers use a combination of ultrasound and vision sensors for navigation. By combining ultrasound data with image data and predicting possible obstacle positions through a pre-trained neural network, the robot can navigate autonomously in a dynamic, unstructured environment [8].

2.2. The Positioning Method of the Mobile Robot
Positioning is to determine the position of a mobile robot relative to the global coordinates and its own posture in a two-dimensional (three-dimensional) working environment, and is one of the most basic links for mobile robot navigation. Depending on the complexity of the robot's working environment and the type and number of sensors installed, different positioning methods can be used. There are two main autonomous positioning methods for mobile robots: relative positioning and absolute positioning [9-10].

The relative positioning methods are mainly as follows:
(1) Use odometer
(2) Inertial positioning
(3) Dead reckoning

There are mainly the following absolute positioning methods:
(1) Based on active beacons (signal lights)
(2) Based on artificial road sign recognition
(3) Recognition based on natural road signs

In actual robot navigation systems, a combination of relative positioning and absolute positioning is often used to locate the robot.

3. Research Experiment of Robot Path Planning Method Based on Genetic Algorithm
In practical applications, the working environment of most robots is dynamic and uncertain, usually with information about static obstacles with unknown locations and information about the movement of obstacles with uncertain trajectories. It contains. Therefore, the problem of avoiding robot obstacles in a dynamic environment is very complicated. This section describes the problem of designing robot routes in a dynamic environment. In a dynamic environment, the robot can be identified in a static global environment, but there are some unknown obstacles.

When optimizing the original global path of unknown obstacles is not considered. The robot starts to start, and when it reaches a certain point, it will find a new obstacle. Currently, the robot can synthesize the detected information and prior knowledge of known obstacles, and redesign the route from now on. Then move from a new starting point along a new route, and find a new obstacle when reaching another point, repeat the above process, and finally the robot reaches the target point. From the simulation experiment, the dynamic path planning algorithm proposed in this paper is feasible.

4. Research and Analysis of Robot Path Planning Method Based on Genetic Algorithm
4.1. Analysis of Environmental Factors
The description of the environment is the basis for the realization of the robot path algorithm. For the structured environment of mobile robots, there are many environment modeling methods. The
The standard for evaluating model quality is not the accuracy or mathematical description that reflects objective reality. Perfect, but efficient in solving route planning problems. The unilateral pursuit of environmental information display accuracy often leads to complexity and affects the stability and robustness of real-time algorithms. Therefore, environmental description should strike a balance between qualitative and speed, and use a combination of qualitative and quantitative methods, and find the best design for a specific environment to properly preprocess environmental information.

The preprocessing of environmental information follows the following principles:

1) The mobile robot moves in a two-dimensional plane, and the obstacle does not consider the height information.
2) Combine short-distance obstacles, that is, if two obstacles are very close to each other, and the distance between the two obstacles is less than the minimum safe distance for the robot to pass, the two obstacles are merged and regarded as obstacles.
3) Extend the obstacle limit to 1/2 of the maximum size of the robot body along the length and width directions. You can treat the robot as a quality point and ignore it.

4.2. Simulation Analysis of Static Environment Path Planning

When applying genetic algorithm to robot path planning, first of all, the occurrence probability of crossover operator, mutation operator and smoothing operator must be set. The fitting function calculation also includes the safety margin value $\lambda$ and the expected deflection angle, so these parameters must be set. Path planning is looking for the shortest path to meet the requirements of safety and smoothness. This is the problem of finding the minimum value. In the next simulation experiment, the smaller the fitted value (or path cost), the better the path.

| Search algorithm | Traditional algorithm |
|------------------|-----------------------|
| frequency | Times | Path length | frequency | Times | Path length |
| 1 | 12.6 | 61.325 | 1 | 13.66 | 64.028 |
| 2 | 13.25 | 63.267 | 2 | 13.31 | 63.713 |
| 3 | 12.85 | 62.007 | 3 | 13.71 | 64.372 |
| 4 | 12.54 | 61.578 | 4 | 13.2 | 63.597 |

Figure 1. Comparison of time and path length between search algorithm and traditional algorithm

In order to verify the adaptability of the algorithm to this article in a complex environment, according to the above two methods, from the above simulation results, the search algorithm seems to have successfully found the approximate best possible path. In addition, the calculation time of this algorithm is slightly longer, but it is basically acceptable. In the future, improvements can be made to increase the effectiveness of the program. At the same time, the algorithm itself is worth continuing to
explore. In terms of hardware, you can consider using better computer hardware in offline programming to reduce programming time, because offline design is performed before the mobile robot starts to move, so the real-time impact on the robot is not as strong as network programming.

4.3. Fitness Parameters
In the basic genetic algorithm, the physical function of the chromosome is the only basis that guides the algorithm to search. This section will analyze the impact of adaptive parameters on the performance of genetic algorithms. In the route planning problem, the fitness function is composed of the length of the route, the safety of the route and the smoothness of the route, which can be divided into two factors: the weighting factor and the safety margin.

In route planning, our goal is to find a relatively stable route as soon as possible under certain safe conditions. Therefore, the main goal is the length of the route, the secondary goal is the smoothness of the route, and the limitation is safety. Obviously, if the route is safe and stable, the length of the route must be increased. Therefore, it is necessary to study the weights of the three in the fitness mode to achieve the goal of balance.

5. Conclusions
This paper mainly studies the path planning method of mobile robot based on genetic algorithm, and proposes a dynamic design method based on the research of robot path planning in static environment. In particular, this article mainly completes the following tasks: (1) Analyze and summarize the main problems solved by route planning and related technologies; (2) use two mechanisms to design different fitness functions. Detailed introduction; (3) MATLAB environment simulates the path planning method based on the genetic algorithm proposed in this paper, and gives the results of path planning, and studies and analyzes the results. However, there are some shortcomings: (1) There is negligence in the research and appearance of the mobile robot; the algorithm can be further improved to suit the 3D environment. I hope to correct these weaknesses in my future life and provide perfect answers for my career.

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