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The Research Overview of Global Path Planning Technology for Mobile Robot

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Abstract

Path planning is a key problem to be solved for mobile robot to realize autonomous navigation, which has important theoretical and application value. Path planning technology is the key factor restricting the intelligent level of mobile robot. If path planning cannot be intelligent, mobile robot will have developed limbs and simple mind, which will affect the transformation and promotion of technology. Taking mobile robot path planning as the research object, this paper introduces the research progress of global path planning and local path planning.

Keywords

Mobile robot; Autonomous navigation; Path planning; Intelligent algorithm; Map.

1. Introduction

Autonomous navigation technology is an important direction of mobile robot research and the core of mobile robot. Since entering the 21st century, more and more attention has been paid to the development of autonomous navigation technology at home and abroad, and it has become one of the most active fields of cutting-edge high-tech research. As a robot motion interaction technology, autonomous navigation technology is one of the three robot bottom technologies in parallel with computer vision and natural language understanding. It is also the key in the field of low-speed unmanned application. Path planning is to find the best obstacle avoidance path for mobile robot in an obstacle environment. The problems to be solved include three aspects: reaching the target point, obstacle avoidance and optimal path under certain indicators.

2. Global Path Planning

Global path planning refers to path planning when the environment is completely known. Based on the commonly used global map models such as grid diagram, visual diagram, Voronoi diagram and quadtree, the optimization algorithm is used to search the optimal path. Traditional global path planning algorithms include heuristic search algorithm, intelligent algorithm and random sampling method, deep reinforcement learning, reinforcement learning algorithm, cloud computing technology and hybrid algorithm have been gradually applied in path planning.

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2.1. Traditional Algorithm

The heuristic search algorithm is based on breadth first search, and the heuristic evaluation function expands along the optimal node. A* algorithm is a heuristic search algorithm, which is widely used in path planning. In recent years, many researchers have proposed improved research and new heuristic strategies for path planning based on the research of A* algorithm. Theta* is a variant of A* algorithm. Shorter paths can be obtained by taking path analysis as part of the search process [1]. In order to improve the operation efficiency of path planning algorithm, reduce the number of traversing grids, implement obstacle avoidance strategy and limit the operation time cost, ADFA* algorithm is proposed to control the algorithm time consumption [2]. Other algorithms such as two-way D* (TWD*), lazy A* search and limited damage A* have also made corresponding improvements to the A* algorithm.

Intelligent algorithm is a calculation method derived from the characteristics and mechanism of natural phenomena or organisms. In recent years, many intelligent algorithms have been applied to global path research and achieved a lot of results. Genetic algorithm, ant colony algorithm, particle swarm optimization algorithm and neural network algorithm are widely used in path planning. Genetic algorithm (GA) is a method to search the optimal solution by simulating the biological evolution process in nature. Reference [3] uses genetic algorithm to find the shortest path from start to end in grid environment. Reference [4] designed a dynamic path planning scheme for navigation and obstacle avoidance strategies in dynamic conditions. Artificial neural network (ANN) is an adaptive nonlinear dynamic system composed of a large number of nodes (or neurons) connected with each other. The neural network is applied to the dynamic programming self-organizing map to improve the convergence speed of the solution of the path planning problem. Particle swarm optimization algorithm originates from Kennedy and Eberbar's research on the foraging behavior of bird groups. It starts from a set of random solutions and finds the optimal solution through iteration. Reference [5] designed a multi-objective particle swarm optimization algorithm for robot path planning with hazard sources. In order to overcome the limitations of robot workspace, Dadgar M et al. [6] proposed a distributed algorithm based on PSO to achieve the overall optimization under the global mechanism. Other algorithms such as artificial bee colony algorithm, firefly algorithm and simulated annealing algorithm are also applied to path planning.

Random sampling method was applied to path planning in the 1990s, mainly including rapid exploring random tree (RRT), probabilistic roadmap method (PRM), expansion space method and Ariadne clue method. The traditional RRT search algorithm was first proposed by Professor Lavalle in 1998. Mashayekhi et al. [7] proposed a hybrid RRT to solve the problems of convergence efficiency when RRT searches the path and time-consuming to optimize the path. Karaman et al. [8] proposed RRT* algorithm, which solves the problem that the path generated by RRT algorithm is not a probabilistic optimal solution, but the operation efficiency is very low in large-scale search.

2.2. Deep Reinforcement Learning

Deep reinforcement learning (DRL) is the product of the combination of deep learning and reinforcement learning. It integrates the strong understanding ability of deep learning on visual perception and decision-making ability of reinforcement learning, and realizes end-to-end learning. The emergence of deep reinforcement learning makes reinforcement learning technology really practical and can solve complex problems in real scenes. Since the emergence of deep Q network (dqn) in 2013, there have been a large number of algorithms and papers to solve practical application problems in the field of deep reinforcement learning. In 2018, Wang et al. [9] introduced the strategic gradient method into the depth enhancement model to realize automatic driving. Chu et al. [10] proposed an indoor path planning model based on depth Q neural network algorithm combined with prior knowledge in 2018. The model can better solve

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the problem of large differences between different indoor scenes, and complete the navigation task only by obtaining the surrounding environment image through the camera sensor. In 2019, Wang et al. [11] proposed using reinforcement learning algorithm to realize multi-agent path planning, using Q-learning algorithm to constantly repeat the process of exploration, learning and utilization, accumulate historical experience, evaluate action strategies and optimize decisions, and complete the path planning task of multi-agent in unknown environment.

2.3. Cloud Computing

The traditional path planning method completely depends on the robot's own computing resources for real-time solution, and the execution speed is slow, which can not meet the needs of real-time path planning. Benefiting from the high speed, high concurrency and low delay of data transmission brought by 5g and other communication technologies, cloud computing technology began to be applied in the field of robotics [12]. Cloud robot is a combination of cloud computing technology and robotics. It uses the powerful storage and computing power of the cloud to improve the robot's ability and reduce the cost of robot's local resources. DaVinci, roboearth, rapyuta and other cloud platforms greatly promote the application of robots by unloading heavy computing into the secure computing environment in the cloud. Under this idea, a new solution to the path planning problem appears, that is, the path planning process is divided into two stages: front-end acquisition and cloud computing. Kamburugamuve et al. Used the distributed processing framework to implement the gmapping algorithm on the iotcloud platform [13]. Lidar and inertial sensor data are sent to the cloud. The cloud carries out map creation and path planning, and the results are returned to the robot. Wang Wei et al. Planned the walking path of the robot through ant colony algorithm in the cloud to meet the task of selecting the optimal path for the robot to avoid obstacles [14]. Gong Zheng uses Hadoop cluster to realize robot map matching and path planning [15].

2.4. Hybrid Algorithm

More and more researchers find that a single path planning algorithm has its limitations. By integrating multiple path planning algorithms, we can better solve the path planning problem. Reference [16] mixed particle swarm optimization algorithm and probabilistic landmark method. Particle swarm optimization algorithm is used for global planning, and probabilistic landmark method is used for local planning to avoid obstacles. The results show that the generated path is shorter and smoother. Reference [17] proposed a strategy of using potential field grid method and quantum genetic algorithm. The proposed strategy can effectively avoid obstacles.

3. Conclusion

As an important branch of robotics, mobile robot is a comprehensive system that can perceive the environment and has the functions of decision-making, planning, behavior control, execution and so on. With the continuous progress of science and technology, the performance of mobile robot has been gradually improved and has been widely used in military, industry, exploration, medical and other fields. The research on mobile robot has also developed to a new stage and has become one of the biggest hotspots in the field of robot. Autonomous navigation is the core of mobile robot. Localization technology, tracking technology, path planning technology and control technology are the most core and fundamental problems of autonomous navigation, in which path planning plays an important role. As more and more scholars carry out research on path planning, the efficiency, quality and adaptability of path planning are continuously improved. In the research of this field, not only the vertical depth expansion, but

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also the horizontal combination of other technologies in autonomous navigation, and finally continue to promote the development of path planning technology.

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