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The Technology Statues and Trend of Path Planning of Logistics Robot

Xiaoying Li[1]

[1]College of Engineering, China Agricultural University, Beijing, China, 100091

xiaoying_li@cau.edu.cn

Abstract. In recent years, the application of logistics robots has become an important means for logistics enterprises to compete in the market. Using logistics robots to pick or transport goods can effectively improve storage efficiency, and how to obtain the optimal path for logistics robots are the focuses of research. This paper introduces the research status and algorithm of logistics robot path planning, and analyzes the research trend and direction of logistics robot path planning technology according to different research. Automated navigation vehicles in logistics robots are developing rapidly, and the safety and efficiency of effective cooperation between AGS have been greatly improved. In terms of algorithms, the main algorithms currently used are A*, Q-learning and genetic algorithm, and the robot has achieved global path planning and path planning in a dynamic environment. At present, the main objective of scholars in robot path planning is to find the shortest walking path in the shortest time. However, in a diversified environment, the objective of robot path planning will be more specific and more realistic.

Keywords: logistics robot, path planning, intelligent algorithm, review

1. Introduction

With the rapid development of the national economy, the market demand for the logistics industry is increasing. Automation technology is more and more widely used in the modern logistics industry. The warehousing process of logistics link needs to go through a manual warehousing stage, a mechanized warehousing stage, an automatic warehousing stage and a comprehensive automatic warehousing stage, which is developing rapidly towards an intelligent warehousing stage. Path planning is a very important part of the development of logistics robots. The accuracy and efficiency of route planning affect the intelligence level of the logistics industry. Therefore, the path planning research of logistics robots is extremely critical. This paper studies the current development status of robot path planning in the logistics industry, analyzes the possible shortcomings in the development, and discusses the future development goals and directions. This paper summarizes the development status and algorithm research of logistics robot path planning in recent years, and on this basis, expands the potential trend of future logistics robot path planning research, which provides a reference for relevant enterprises using logistics robots and the future research of logistics robots.

2. The reseach status

With the influence of intelligent logistics gradually expanding, the practical application of mobile robots in logistics has become one of the research focusses. In much robot research, the Automated Guided

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Vehicle (AGV) is not only the focus of attention, but also has a good application in practical selection. At present, the main representatives in the field of AGV are as follows :① Kiva robot developed by Amazon (as shown in Figure 1(a)) can automatically pick and pack goods in large warehouses by collecting two-dimensional code information on the ground, while employees only need to complete distribution at a fixed location, greatly improving work efficiency; ②Fetch Robot from Fetch Robotics (as shown in Figure 1(b)), which has arms with 7 degrees of freedom and automatic navigation, can independently pick up goods and put them into a "moving basket" named Freight; ③ Transwheel robot (as shown in Figure 1(c)) developed by Israel Shenkar Institute looks like a "unicycle" in traditional acrobatics. It has self-balancing function and can complete tasks independently or combine multiple tasks together to jointly complete the transmission of large goods. ④Contour navigation AGV developed by Shenzhen Jiashun Intelligent Robot Company (as shown in Figure 1 (d)) adopts odometer assisted laser reflector for positioning and navigation, and has the omnidirectional walking function.

Figure 1(a). Kiva robot.

Figure 1(b). Fetch robot.

Figure 1(c). Transwheel robot.

Figure 1(d). Contour navigation AGV.

The research of AGV is mainly focused on path planning, and different algorithms are applied to design the AGV running route combining with the actual problems.

When multiple AGVS work at the same time, there may be different forms of thrust between them, at which time AGVS need to conduct obstacle avoidance research.Liu Jingyi proposed the warehousing task scheduling and vehicle scheduling strategy based on the shortest task waiting time, divided the warehousing tasks into priority, and proposed the algorithm based on priority queue and locking node time window, and finally found the optimal path. Considering the time window in path planning, the path section is blocked during this period, which effectively avoids the collision between the AGV and other AGVs, but also increases the running time of other AGVs to a certain extent, affecting the overall storage operation efficiency[1].Meng Chong used a variety of genetic algorithms to carry out path planning. They first generated the path library in the offline state and then adjusted it online according to the real-time state[2].

In the work of AGV, in addition to the research on obstacle avoidance, the cooperation between multiple AGVs should also be considered. In order to achieve effective coordination among multiple AGVs, ZhangY prioritizes the remaining power of the AGV battery, defines a redundant time period to improve the security of avoidance, and uses the improved algorithm to get the optimal path[3]. ElazaryL prioritized the assigned tasks to reduce the waiting time of the robots[4].

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3. Path planning related algorithms

Basically, the path planning of a logistics robot is accomplished by an algorithm. Algorithms are divided into deterministic algorithms and non-deterministic algorithms, and the mixture of these two algorithms is called evolutionary algorithms[5]. In recent years, the development of evolutionary algorithms and other intelligent algorithms has made great progress in the path planning of logistics robots. These intelligent algorithms include the A* algorithm, genetic algorithm, Q-learning algorithm, particle swarm optimization algorithm, fuzzy algorithm, neural network algorithm, artificial potential field algorithm, bacterial foraging algorithms, firefly algorithms, etc.

3.1. A∗ algorithm

The A∗ algorithm has been widely used in the path planning of logistics robots. As an important heuristic algorithm, it is mainly used to select the shortest path between two points. A* algorithm is realized by A valuation function F=G(n)+H(n), which is an important factor affecting the efficiency and advantages of A* algorithm. G(n) is the minimum cost of the path from the starting point to point n, and H(n) is the minimum estimated cost of the path from point n state to the target state, where, the key of the estimation function is the choice of the initiating function H(n). The closer the value of H(n) is to the actual optimal value, the higher the search efficiency will be.

Manhattan adds path cost and time waiting cost to improve and modify the A* algorithm, realizing path planning under special road rule constraints[6]. Angle constraint is carried out on the A* algorithm from the perspective of reducing the number of path Angle. This reduces machine loss and improves the efficiency of logistics robot path planning[7]. The deficiencies of three commonly used distance algorithms in the traditional A* algorithm are improved, and A complex diagonal distance algorithm is proposed to carry out path planning for robots[8]. Huang Baiyue improves the predefined expansion mode of four nodes or eight nodes in traditional A* algorithm, calculates the specific coordinates of the neighborhood with an evaluation function, and searches for nodes with the best evaluation value in the neighborhood to improve the A* algorithm[9]. Wang Hongbin proposes an improved A* algorithm, which can only retain the starting point, turning point and end point in the path. Aiming at the problem of A∗ algorithm with a large number of turns, the dynamic tangency method is introduced to smooth the planned path and realize the global path planning of the robot. [10]

3.2. Q - Learning algorithm

The Q-learning algorithm is a kind of reinforcement learning that is widely employed in intelligent control and robotics. We're going to start with an arbitrary initial value before we explore the environment. Then, with the exploration of the environment, Q-table will update Q-table iteratively using dynamic programming equations to obtain better and better approximations. Among them, reward and punishment functions in the Q-learning algorithm are applied to guide and judge the advantages and disadvantages of robot operation effects.

Chen Mingzhi sets up appropriate reward and punishment mechanisms to accelerate the convergence and accuracy of Q-learning algorithms, and uses Manhattan Path to estimate the path cost to optimize the algorithm structure[11].

At present, the Artificial Potential Field method has been introduced into the process of q-value initialization, which solves the common problems such as slow convergence speed and poor path smoothness when the existing mobile robot uses reinforcement learning method to carry out path planning. In the local path planning algorithm based on Q-learning, researchers reasonably consider the number of environmental regions and space states, and design a continuous reward function on this basis, so that the robot can timely feedback the performance of the action.

3.3. Genetic algorithm

Compared with other intelligent algorithms for robot path planning, genetic algorithm is more widely used, more frequently employed and has more clear advantages. Therefore, there are many papers on genetic algorithm in the research of logistics robot path planning in recent years. Genetic algorithm in path planning problem solving process, the general is randomly generated initial population, the way to get the solution of poor quality, so usually use nearby algorithm, greedy algorithm and other methods to improve the quality of initial group, and because of poor local search ability of genetic algorithm and slow convergence speed, easy to fall into local optimum, researchers often combines genetic algorithms and other intelligent algorithm in a Solve the problem.

Elshamli A proposed a genetic algorithm for solving static and dynamic path planning problems of mobile robots[12]. Tuncer A proposed a new genetic algorithm mutation operator and applied it to mobile robot path planning in a dynamic environment, and verified the superiority of the improved genetic algorithm[13]. Han Z adopted the dual-path constraint of minimizing the total path distance of all AGVs and the single-path distance of each AGV, and proposed an improved genetic algorithm to solve the path planning problem of multiple AGVs[14].

This paper compares path planning algorithms, as shown in Table 1.

Table 1. Path planning algorithms.

Algorithm name	**characteristics**	**methods for improvement**	**Application Environment**
A* algorithm	Fast response to environmental information, easy to understand, but time and space consumption	Improve its valuation function	It is often applied to static low - dimensional path planning problems
Q - Learning algorithm	It can realize real-time and fast reaction of road condition information, but if the reward value is set improperly, the convergence speed is slow	① Optimize the design of reward and punishment functions ② Introduce transfer learning mechanism to improve initial learning efficiency	It is often used in adaptive optimal control, path planning and control, artificial intelligence and other fields
Genetic algorithm	It has global search property and is easy to be combined with other algorithms. The solution is approximate optimal, but the convergence speed is slow	① Improve the generation mode of initial population ② Improve the crossover strategy ③ Improve the mutation strategy	Often used in task allocation, path planning, production scheduling, automatic control, machine learning, data mining and other problems

4. Trend of path planning of logistics robot

At present, with the vigorous development of the market economy and the gradual individuation and diversification of demand, the path planning of logistics robots is bound to put forward higher requirements.

A logistics robot will tend to use sensors as an auxiliary and an algorithm model as the main navigation mode. For the navigation of logistics robots, the precision of navigation should not be excessively required, and the navigation mode with fast response speed should be the first choice. Therefore, the high-precision positioning relying on sensors will gradually shift to the navigation mode with sensors as the supplement and algorithm model as the main model.

The objective of logistics robot path planning will be more relevant to the current situation. At present, the main objective of scholars in robot path planning is to find the shortest walking path in the shortest time. However, in the diversified warehouse environment, the objective of robot path planning will be more specific and more realistic.

A variety of new intelligent algorithms and hybrid intelligent algorithms will become the mainstream of logistics robot problem solving. A single intelligent algorithm can no longer meet the needs of practical development. Multiple algorithms are combined to improve, learn from each other, and continuous optimization is bound to bring more satisfactory solutions. For example, the direction guidance of an artificial potential field is good, and it is often combined with other algorithms as direction guidance parameters. At present, most of the researches of scholars stay on the traditional swarm intelligence algorithm. However, with the continuous development of social sciences, some new intelligent algorithms have fewer step-by-step algorithm parameters, relatively simple evolution process, fast calculation speed, and stronger global search ability, which can be widely adopted in high-objective and multi-objective optimization problems.

5. Conclusion

This paper summarizes the development status and algorithm research of logistics robot path planning in recent years and can draw the following conclusions. Autonomous guided vehicles are developing rapidly in logistics robots, and the safety and efficiency of effective cooperation between AGS have been greatly improved. The main algorithms currently used are A*, Q-learning and genetic algorithm. The robot has realized global path planning and path planning in a dynamic environment. At present, the main goal of robot path planning is to find the shortest path in the shortest time. However, in a diverse environment, robot path planning goals will be more specific and realistic. According to different studies, it can be seen that the current path planning research still has some problems, such as insufficient power of logistics robot, sudden failure of logistics robot and a large amount of data processing before logistics operation is not timely. In the future development of logistics robot path planning algorithm, some new intelligent algorithms are gradually born. These algorithms have fewer parameters, a relatively simple evolution process, fast operation speed and stronger global search ability, which can be widely used to solve high and multi-objective optimization problems. In the future development of logistics robot path planning algorithm, some new intelligent algorithms are gradually born. These algorithms have fewer parameters, a relatively simple evolution process, fast operation speed and stronger global search ability, which can be widely used to solve high and multi-objective optimization problems.

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