Visual Navigation and Path Planning of Ball Picking Robot based on Swarm Intelligence

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Abstract. With the progress of science and technology, intelligent robot system has been applied in service industry. The research and design of service-oriented autonomous mobile robots have attracted more and more attention from enterprises and businesses. In this paper, an intelligent tennis pickup robot based on swarm intelligence is designed around the collection of tennis on the tennis court. Firstly, the paper briefly describes the purpose of the path planning of the Ryukyu robot and the working characteristics of the visual processing. It analyzes the problems faced by the design of the autonomous ball-racing robot. Then, based on the rolling window theory, an autonomous mobile robot based on the visual sensor is proposed. Multi-objective path planning algorithm. The algorithm effectively reduces the time for the mobile croquet robot to perform tasks and improves its croquet efficiency.

Keywords: Swarm Intelligence, Tennis Picking Robot, Visual Navigation and Path Planning.

1. Introduction

Intelligent robot is a kind of robot which has the ability of sense and recognition and can control its own behavior. The goal of robotics is to develop highly automated intelligent robots [1]. So far, the development of robots has roughly experienced programmed control robots, adaptive programmed control robots and intelligent robots. In tennis teaching and practice, especially in multi-ball and serve practice, picking up the ball is the most headache [2]. Ball-picking robots will take the place of human beings to complete the boring task of picking up balls. Autonomous intelligent mobile robot is a hotspot in the field of robotics research in the world. Path planning is an important part of intelligent mobile robot. Its research purpose is to enable robots to plan their own path in different environments [3]. However, while the ball sports bring health and happiness to people, people have to face such a real problem: they must constantly pick up the spheres scattered in every corner of the stadium, which consumes a lot of physical strength and time. Therefore, this time-consuming and laborious croquet task can be accomplished by using the croquet robot [4].

But tennis is a very physical exercise, so many people who practice tennis will carry a lot of tennis balls to avoid the trouble of picking up. However, this leads to the tennis court full of tennis after a period of exercise [5]. This not only hinders the exercise of the person to serve the ball, affecting the fun of exercise, and because of the tennis ball, the exerciser is very likely to accidentally step on the tennis ball during the move and cause a fall, and even more may be subject to greater physical injury [6]. The ball-picking robot studied in this paper is different from other mobile robots because its moving destination is acquired by vision in real time and the number of target points changes dynamically. Ball-picking robot is different from general mobile robot. It is a vision-guided multi-target search mobile robot [7]. The vision sensor captures the tennis image and locates it. After path planning, the robot arm is used to grasp the tennis accurately. It can replace manual picking up balls in tennis training and competition, reduce sports injury and improve tennis sports efficiency [8].

2. Methodology

When designing an autonomous mobile ball-picking robot, we need to consider such factors as design cost, robot quality, battery type and power. These factors are interrelated, for example, the choice of battery type and power is directly related to the final cost of the robot, and the quality of the robot is directly related to the choice of the robot battery [9]. The idea of picking up balls is to establish a two-dimensional plane coordinate system under the condition that the environmental

information is determined, that is, the position information of each tennis point is known. The robot collects tennis picture information by controlling the camera installed above the tennis court. After receiving the picture, it processes the image and extracts the tennis position. The robot motion control software applies the ant colony algorithm to process the tennis position information and generates a croquet optimization path [10]. The robot-driven motion mechanism moves in accordance with the path generated by the algorithm and performs a ball-carrying action. When the robot moves closer to the tennis ball, the croquet mechanism begins to move until the tennis ball is picked up. The remote monitoring terminal used in conjunction with it can view the working state of the Ryukyu robot in real time and can be easily controlled.

Robot vision navigation and path planning technology based on swarm intelligence has been popularized and promoted in all walks of life. The different application scenarios result in various forms. According to different standards, it can be divided into different categories. Its main classification is shown in Table 1.

Table 1. Different classification methods of visual navigation and path planning for different standard robots

Standard	Type
Guidance mode	Electromagnetic Guidance, Laser Guidance, Visual Guidance
Driving mode	Wheeled, caterpillar
Guidance Path Form	Fixed Path, Free Path

In machine vision and image processing, binary image and gray image have been widely used, mainly because of the use of binary form in computer processing and data representation, and biological vision has no difficulty in understanding these two images. Because the quality of the robot is related to the amount of work done by the robot to overcome ground friction when moving, and the energy provider of the robot when moving is the battery loaded on the robot. In order to improve the efficiency of picking up balls, it is necessary to minimize repeated scanning and walking distance in some areas, and to ensure that the search of the whole space can be completed. There are many drive motors required, and the natural hardware cost will be higher; some of the energy consumption between the motors cancels each other out, so the energy efficiency is low. Compared with the omnidirectional motion mechanism, the control of the two-wheel differential motion mechanism is relatively simple and easy to implement, but the disadvantage is that the rotation flexibility is poor. The intelligent croquet robot uses image processing technology to greatly improve the efficiency of the croquet. The multi-sensor fusion technology makes the implementation of obstacle avoidance and counting functions simpler, saves hardware resources, and improves code execution efficiency.

The croquet robot involved in the article is a self-designed intelligent croquet robot suitable for tennis, table tennis and other sports venues. It belongs to the autonomous mobile croquet robot. Due to the unique design of the robotic motion device, it can be steered at any angle in situ without the problem of turning radius. Figure 1 shows a prototype of a smart croquet robot.

Fig. 1 Prototype of intelligent croquet robot

Then travel path planning for multiple tennis balls to find the first target. The driving motor rotates the traveling mechanism so that the target tennis ball is located at the center of the visual window. Thereafter, the robot moves toward the target tennis ball. When the tennis area reaches the set value, the robot stops walking, and the mechanical claws grab the tennis ball through the solidified mechanical arm movement process. . For the mobile robot to get the environmental information on the field, the sensor system must be installed. For mobile robots, the sensor system is an integral part. The sensor system consists of an internal sensor and an external sensor. Internal sensors mainly include odometer and photoelectric encoder, while external sensors are mainly visual sensors, which are acted by USB camera. When the robot is full of spheres, the robot will send the full ball information to the control terminal through the wireless communication network, and then inform the staff that the sphere is full through the control terminal. In addition, when the power of the ball picking robot is insufficient, it falls into trouble or stops picking balls for a long time, it will also notify the remote monitoring terminal through wireless communication. The realization of remote monitoring terminal greatly improves the efficiency and practicability of ball picking robot.

3.   Result Analysis and Discussion

The essence of robot path planning is to find an optimal mobile path for the robot in the working environment. If all the external environment information is known, we can get the optimal path through effective algorithm. Environmental model is an important part of robot path planning. The method of planning is decided by the completeness of environmental information and the form of environmental model. The workspace of mobile robot is a real physical space, and the space dealt with by path planning algorithm is the abstract space of environment, which is called environment model. The setting of grid size in grid environment directly affects the search efficiency of the algorithm, and even affects whether the algorithm can complete the task of path planning in a suitable time. In the same environment, the smaller the grid partition, the more accurate the information representation of each location in the environment, and the more storage, which makes the actual search space of the algorithm larger. Since each planning is performed within a small limited window, it can not only solve the path planning problem when the global environment is unknown, but also has the speed and high speed.

The end of the arm is the gripping mechanism. Considering the overall quality and stability of the robot, the design principle of the robotic gripping mechanism is light, simple, controllable and shrinkable, and the design is slim and simple. as shown Figure 2.

Fig. 2 Grab the tennis state map

A certain number of tennis balls are scattered on the tennis court, and the starting point and ending point of the croquet robot are set. The starting point and the ending point are counted as one tennis ball. Among them, the starting point and the ending point can be set to the same position, or can be in different positions. In the text, the starting point and the ending point are set at different positions, so as to reflect the flexibility that the starting point and the ending point can be freely set as needed,

and the utility is emphasized. According to the environmental information of the real-time feedback of the sensor, the path of the auto-guided car is adjusted and planned in real time by the host computer. The working environment in local path planning is dynamic. With the change of environment, the path can be adjusted accordingly. Therefore, the real-time performance is strong, but the requirement of technology is relatively high. The whole manipulator is designed to move in a vertical plane. On the one hand, it is easy to control the precise positioning of the manipulator, on the other hand, it can also reduce the computational burden of the control system, which is simple and practical. The motion of the manipulator obeys the preset fixed action. After the signal of picking up the ball is given by the processor, the movement of the manipulator is controlled by the established program, and the specific actions of stretching, bending, grasping, transferring and throwing are completed.

When the search process of the algorithm satisfies the mutation condition, the obtained path is mutated. When choosing the path to be mutated, there is no special requirement for the path to be mutated. In the process of each mutation, the number of paths to be mutated can be set independently or be mutated according to the default parameters. At each step of rolling, the robot detects local information according to vision, and then generates optimized sub-targets by visual navigation. Perform local path planning in the current rolling window, then implement the current strategy (moving one step according to the local planning path), and continuously obtain new environmental information as the rolling window advances, thereby realizing the combination of optimization and feedback in the rolling. Assuming that the running speed of the automatic guided vehicle is known and uniform, the time cost is at least the shortest distance, so the path planning is essentially to find the shortest travel problem. Considering different environment-aware conditions, such as known, partially known, unknown environment path problems, consider using different search algorithms, so path planning technology has always been a major problem in the research of key technologies of tennis croquet robots.

4. Conclusion

Multi-objective path planning is a core technology of robot research. It has been widely used in the fields of drone inspection, traveling salesman problem, vehicle route planning problem, emergency evacuation route design, logistics distribution optimization, etc. Extensive attention and research. This paper proposes a path planning scheme based on visual target detection mobile robot based on group intelligence and rolling window. The vision-based path planning scheme of the autonomous mobile ball-picking robot takes full account of the actual working environment of the tennis court and effectively improves the efficiency of the ball-picking robot. It can improve the training efficiency of tennis fans and athletes, save time and effort in tennis matches and training process, adapt to the current trend of health, sports and intelligence, and have a good development prospect. At the same time, it combines well with the design goal of the ball picking robot, and can be competent for the ball picking task of the autonomous ball picking robot.

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