Functional module design based on intelligent cleaning robot

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Abstract: In this paper, the functional design of intelligent cleaning robot is studied in depth. Ankai micro development board is used as the core, and advanced technologies such as machine vision and laser radar are integrated to realize accurate garbage identification and classification. Through the lightweight YOLOv5s neural network, the rapid detection of objects is realized, and the mechanical arm is used to perform garbage picking. The random coverage method is used for path planning to ensure comprehensive cleaning, and the improved Bug2 algorithm improves the efficiency of obstacle avoidance. The system design aims to improve the cleaning efficiency, reduce the cost and promote environmental protection, which indicates the wide application prospect of intelligent cleaning robot in the future.

Keywords: Cleaning Robot; Image Recognition; Path Planning

1.Introduction

The sweeping robot is a smart home device that can clean the floor autonomously and reduce people ‘s housework burden. It usually uses advanced sensors and navigation technology, which can automatically perceive and avoid obstacles, and clean according to the different materials and fouling degree of the floor[1]. The shape of the sweeping robot is generally disc-shaped, with a bottom rotating brush and a suction port. Some high-end models are also equipped with high-precision navigation equipment such as lidar or camera[2] to more accurately perceive the surrounding environment.

Sweeping robots have many advantages. First of all, it can reduce people’s housework burden, save time and energy. Secondly, it is able to sweep some areas that are difficult to clean, such as under the bed, the bottom of the furniture and the corner. In addition, the sweeping robot has a low noise level and does not interfere with the rest and work of family members[3]. However, sweeping robots also have some limitations. Due to its smaller size and lower cleaning capacity, it may not completely replace the traditional vacuum cleaner. For some special dirt or ground types, additional cleaning measures may be required.

The world’s first mass-produced intelligent sweeping robot was launched by the home appliance giant Lex in 2001[4] and named it ‘trilobite ‘.Designers hope that this product can climb every inch of the world like arthropods. IROBOT, an American robot expert, has been committed to the research and development of Roomba series sweeping robots since 2022[5].Since the development of this series, in addition to the significant optimization of energy saving, size, appearance and noise, the biggest technological innovation is the embedding of ‘optimization algorithm’. South Korea’s Ottoro vision robot[6], equipped with multiple ultrasonic detectors and two cameras. The laser projection installed on the charging pile projects the navigation map onto the ceiling, and the robot determines its position according to the navigation map. The robot will automatically avoid obstacles based on the information collected by the detector.

This paper refers to the characteristics of intelligent cleaning robots such as garbage identification and manipulator picking, and uses machine vision and image recognition algorithms to accurately identify different types of garbage. By analyzing the camera to capture the image, the garbage type can be distinguished and processed. The path planning algorithm is used to quickly plan the optimal picking path according to the environment map and the target location. By combining map data and real-time sensor information, robots can avoid obstacles, optimize travel paths, and efficiently collect garbage. This paper enables the intelligent garbage picking robot to classify and collect garbage more accurately and efficiently, reduce labor costs, improve garbage disposal efficiency, and reduce the impact on the environment, bringing greater convenience.

2. Design of cleaning robot function module

This paper mainly studies the car using the development board (Ankaiwei) as the main control. We use the energy module, laser radar, encoder, WiFi module, mechanical arm module, motor drive, camera and other hardware to complete object recognition, garbage pickup, path

planning, automatic obstacle avoidance. The object detection function module we currently use pycharm + python + pytorch-gpu + Yolov5s algorithm for programming. The interface is shown in Figure 1.

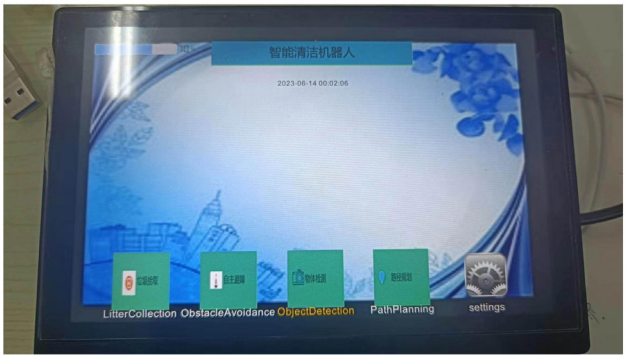

Figure 1 Function display interface

2.1 Algorithm introduction

Considering the hardware itself and the need to quickly detect items and costs, this paper uses a lightweight YOLOv5s neural network for training to realize the recognition of U disks, keys, and rings.

The YOLO neural network structure first inputs a 480* 480 picture, passes through a certain number of convolutional layers and pooling layers, and finally passes through two fully connected layers to generate an output of 7*7*30. Considering the hardware itself and the need to quickly detect items and costs, this paper uses a lightweight YOLOv5s neural network for training to realize the recognition of U disks, keys, and rings. The YOLO neural network structure first inputs a 480*480 picture, passes through a certain number of convolutional layers and pooling layers, and finally passes through two fully connected layers to generate an output of 7*7*30.

2.2 Cleaning robot garbage pickup module

The main function of the module is to process the detected items. If it is banana peel, paper scraps and other garbage items, the main control command is issued through the Ankai emblem board to control the manipulator to clamp the items into the garbage bin. In order to grasp objects efficiently and accurately, the robotic arm needs to combine various technologies such as target recognition and position estimation, path planning and precise control of machine fingers.

2.3 Cleaning robot path planning module

In this paper, the random coverage method is used for path planning, which means that the robot attempts to cover the working area according to a certain mobile algorithm, such as triangle and pentagon trajectory. If obstacles are encountered, the corresponding steering function is performed. This method is a low-cost strategy that trades time for space, such as 100 % coverage regardless of time. The random coverage method does not need to locate, nor does it have an environmental map, nor can it plan the path, so its moving path basically depends on the built-in algorithm, and the pros and cons of the algorithm also determine the quality and efficiency of its cleaning.

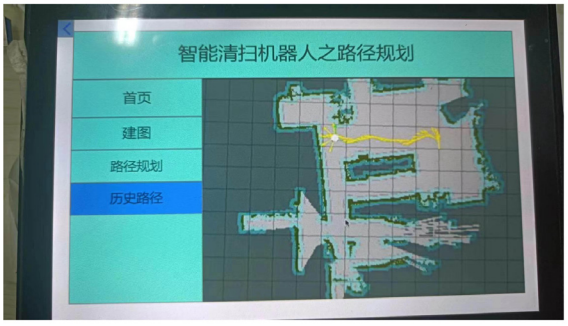

Figure 2 path planning display interface

2.4 Cleaning robot automatic obstacle avoidance module

The task of the obstacle avoidance algorithm is to update the target trajectory in real time and bypass the obstacle because the input of the sensor senses the existence of the obstacle when the robot performs the normal walking task. The Bug algorithm is a simple obstacle avoidance algorithm. Its basic idea is to walk around the detected obstacle contour after finding the obstacle, so as to bypass it. There are many variants of the Bug algorithm, such as the Bug1 algorithm. The robot first completely revolves around the object and then leaves from the point with the shortest distance from the target. The efficiency of the Bug1 algorithm is very low, but it can ensure that the robot achieves the goal.

In this paper, the improved Bug2 algorithm is adopted. At the beginning, the robot will track the contour of the object, but it will not circle around the object completely. When the robot can move directly to the target, it can be separated from the obstacle directly, so as to achieve a relatively short total path of robot walking. In addition, there are many other variants of the Bug algorithm, such as the tangent Bug algorithm and so on. In many simple scenarios, the Bug algorithm is relatively easy and convenient to implement, but they do not take into account the limitations of the robot ‘s dynamics, so it is not so reliable and easy to use in more complex actual environments.

3.Conclusion

Based on the existing technology, this paper designs a set of garbage cleaning robot with garbage picking as the main object. The specific functional framework of each part is established, including movement, recognition, clamping, radar monitoring and so on. The wireless communication technology is used to realize the intelligent connection between the mobile terminal and the product, and the motor is used to control the movement of the car and the movement of the manipulator. Machine vision is used to realize the recognition and picking function of garbage. Laser radar monitoring is used to realize automatic obstacle avoidance function. The cleaning robot designed in this paper can choose a variety of modes, and can also control the movement and picking of the robot through the mobile terminal. In the future, garbage pickup robots will play a greater role in cities and communities. As technology continues to advance, these robots will become smarter, more efficient, and able to adapt to the needs of different environments and tasks.

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