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The Blind Corner Intelligent Cleaning Assistant Based On Sweeping Robot

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Abstract - *Data shows that there is a huge potential for the development of sweeping robots in the home furnishing market. In the daily use of robots, the degree of realization of cleaning, route planning is the most concerned aspect of consumers. In this paper, we introduced the design of an auxiliary plug-in, which is based on the sweeping robot on the consumer market. The plug-in is designed for cleaning blind corners under the sofa and bed, as well as at the wall corner. The plug-in has features of visual, electronic control carried by a set of hardware. The hardware will be introduced in this paper. The test shows that the blind-corner intelligent cleaning assistant based on the sweeping robot has good practicability and universality and can make the cleaning more efficient without changing the original structure of the robot.*

Keywords — *Sweeping robot, cleaning blind corner, auxiliary plug-in, visual recognition*

I. INTRODUCTION

At present, China's domestic market development trend is that the digital appliances market of the traditional home is gradually mature, and intelligence leads a new wave to drive the industry to upgrade[1]. The sweeping robot is a typical intelligent product of rapidly developing science and technology, and its emergence has solved most of the cleaning problems in homes, offices, and other places.

Data shows that although the market of the sweeping robot has great potential, the popularity and coverage rate are not high[2]. At present, although the mainstream sweeping robot can meet the daily cleaning requirements, saving consumers a lot of cleaning time. Now to clean the dust in a small area, clear or clean hair is easy for the sweeping robot. There is still a lot of blind Anglecaused by robot path planning. And because the initial design is targeted atfloor cleaning, the place such as sofa, bed bottom side plate will not be cleaned. The result would be the accumulation of dirt. Sometimes when the robot is working, the accumulated dust will drop down because of the vibrate of the robot working. This lead to the workload raise and cleaning quality downgrade. The sweeping robot is designed to fit in with the fast pace of life of modern people and save us the time of cleaning.

Therefore, it is urgent to solve the problem of cleaning the blind corner of the sweeping robot. This paper designed an auxiliary cleaning plug-in for the bottom of the bed or the bottom of the sofa and an auxiliary plug-in for the corner or corner of the wall, aiming at the cleaning of the sweeping robot to be more efficient and effective.

II. DESIGNOFAUXILIARYCLEANINGPLUG-IN

The original design of the sweeping robot is to fit in with the extremely fast pace of life of modern people and save us the time of cleaning. However, although the strong suction of the sweeping robot can effectively clean the dust and hair in the small areas that are not easy to clean, such as the bottom of the bed and the bottom of the sofa, But there is still a lot of blind Angle because of the robot path planning and its initial design. Such as the bottom of the sofa, the place such as the bottom sides of the bed, is not cleaned by the robot, and lead to the accumulation of dirt, and sometimes because of the robot's working shake, dirt drops down, cause the ground clean cannot effectively complete, This leads to redundancy and repetition of the workload. The schematic diagram of the traditional sweeping robot is shown in Fig 1.

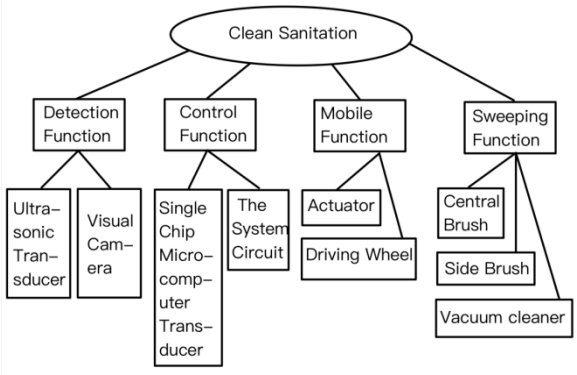

Fig.1 Schematic diagram of the traditional sweeping robot

To effectively improve work efficiency, sweeping robot intelligence clean house corner, based on the above mechanical working principle diagram, designed for different building corner or indoor cleaning disinfection

sweeping robot plug-in, effective use of the robot hardware and original sensor-based, cost savings to make the plugin minimalist design, easy installation, low cost. The schematic diagram of the sweeping robot plug-in is shown in Fig 2.

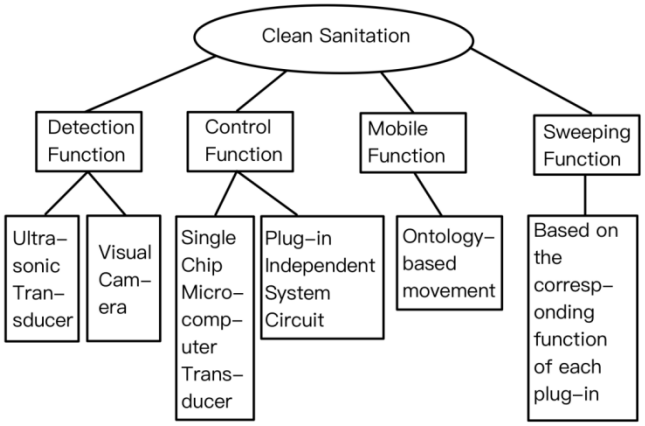

Fig.2 Schematic diagram of traditional sweeping robot plug-in

A. Auxiliary cleaning plug-inforbed bottom or sofa bottom plate

For cleaning the bottom of the bed, under the coffee table, under the sofa, and other narrow and dark places, although the sweeping robot can effectively clean the ground, but can not clean the bottom side of the sofa, bed bottom plate, and other places such as dust and dirt directly cleaning plug-in: Shrinkage state and the surface of the sweeping robot fit together, in the dark area, the light sensor signal transmission, so that the plug-in will clean plane lift until the force sensor installed on the plane to get a signal (that is, clean plane and the bottom of the sofa or bed at the bottom of the joint) and stop lifting lock, The blind corner dirt is cleaned by self-replaceable cleaning tools such as electrostatic paper, brush, and sponge installed on the clean surface.

B. Auxiliary cleaning plug-in for the wall corner

According to the advantages and disadvantages of the commonly used cleaning components of the sweeping robot in the market and the cause analysis of the blind corner problem, the mechanical scheme is obtained: the floating suction and the floating V-type brush are combined, and the two can be automatically switched according to the ground condition; Floating suction components are selected for the hairy ground environment to avoid the fault caused by hair entanglement. A floating V-type brush is selected for the ground environment with more dust and particles, which can clean the electrostatic dust adsorbed on the ground. In addition, both brush types have a floating structure, which automatically adjusts the distance from the ground according to different surfaces, allowing the fiber brush to penetrate into the gaps for deep cleaning, improving the cleaning intensity.

Considering the different sweeping robots on the market correspond to different sizes, in order to make the plug-in can match different sweeping robots, the design of the movable clip and adjustable installation clip to adapt to the compatibility of different sweeping robots.

III. HOWTHEAUXILIARYPLUG-INCLEANINGASSISTANTWORKS

A. Visual Part

The algorithm and image recognition part is designed to increase the cleaning ground material recognition, a variety of corners and blind corners recognition, bed bottom sofa bottom, and other corners recognition for the sweeper as a whole. The blind corner assistant with the recognition ability can decide the strength of the cleaning according to the situation and sweep to the place beyond the reach of the general sweeping robot.

In order to achieve a better recognition effect[3], in addition to the use of visual camera, distance sensor, gray sensor, and laser transmitter are also selected to assist recognition. Among them, the grayscale sensor is an analog sensor. The grayscale sensor uses different color detection faces to reflect different degrees of light, and the photosensitive resistor carries out color depth detection to determine what kind of material the ground is based on the principle that the resistance value of light is returned by different detection surfaces is also different. A distance sensor, also called a displacement sensor, is a kind of sensor, which is used to sense the distance between it and the wall to judge whether it is close to the wall. The laser emitter emits a strong beam and produces a light spot on the wall near the distance. After the image of the light spot is preprocessed, it is compared with the gray threshold to judge the current working condition.

B. Electric Control Part

a) Identify Part

In terms of identification, a visual SLAM algorithm[4] based on ROS operating system is used to realize map building, positioning, and navigation. When the sweeping robot is in an unknown environment, it will conduct self-positioning while moving and build an incremental map on the basis of self-positioning. According to this map, the robot can be set which line can pass, which can not pass, so as to realize the path planning and obstacle avoidance of the sweeping robot. Zed binocular camera is selected as the camera. A binocular camera can calculate the pixel depth through the stereo vision principle, so there is no unknown depth in monocular SLAM. The advantage is that the adaptability to the environment is higher than that of monocular SLAM, and the true pixel depth can be calculated. In addition to the camera, IMU(Inertial Measurement Unit) is also added for fusion. The attitude angle and angular velocity obtained by IMU can filter and optimize the data obtained by the binocular camera. In

addition, if necessary, other sensors such as laser sensor, gray sensor, an ultrasonic sensor can be added to optimize.

b) Control Part

In terms of control, STM32[5] is used as the lower computer to control the movement of the robot. The path planning is carried out after the sweeping robot recognizes the robot, and the data packet is sent to the lower computer through serial port communication. After the data is parsed by the lower computer, the corresponding movement and cleaning are completed. In addition, the ESP8266 module is also added to interact with the mobile phone. Through the mobile APP developed, the robot can be selected to clean a specific room or corner.

C. Hardware Part

The main control chip of the control circuit uses STM32F103ZET6 chip, which is a 32-bit microcontroller based on the ARM Cortex-M kernel STM32 series. The main frequency is 72MHz, with a total of 144 pins; it can simultaneously control the linkage of multiple sensors and communicate with the upper computer to complete the overall control idea.

The motor driver used in the control circuit is L298N motor driver chip, the highest output current is 2A, the power supply voltage is 4.5V to 4.6V, can drive two motor drivers at the same time, drive the DC motor, just change the logic level of the input end, you can realize the positive and negative rotation of the motor drive, The two L298N are respectively connected with the PB1, PB2, PB3 and PB4 of the main control chip, and each pin of the four can be led out at the same time, and each sensor can be added.

The step-down circuit mainly adopts two chips, TPS5430 and LP5907MFX, equipped with the corresponding BUCK circuit topological inductor, capacitor, diode, and other components, to achieve the powerful effect of 12V power input, 5V power output, and 3.3V power output, and to achieve 12V to 5V and 5V to 3.3V.

A serial port connecting the ESP8266 Bluetooth module and ZED binocular camera is also set on the main control board to facilitate the control between the two.

IV. EXPERIMENTALVERIFICATION

In the ground material identification part, the most common gray sensor on the market is selected to measure the reflective value of the ground. It is generally believed that the ground with a gray value of about 40 is a solid wood floor, so the gray value below 50 is set as the floor cleaning condition, while the surface of the ceramic tile is more smooth and the reflectance is higher. Therefore, the gray value higher than 50 is regarded as the ceramic tile cleaning condition, and the initialization procedure is done. When the gray value changes greatly, the system will automatically take the average of the two gray values as the threshold for switching the two conditions.

For the part that allows the system to identify the corner of the wall, it builds on the original cleaning function of the sweeping robot along the wall and carries out real-time distance detection on the direction of travel and the direction of the edge. On the basis of the original path planning of the sweeping robot, the current working condition is judged, and then the blind garbage is processed. Then the system does not need to independently find the wall, the bottom of the bed, and the bottom of the sofa, but it is judged on the current working condition. The laser pointer is used to generate a strong beam to produce a light spot on the wall near the distance, and the visual system is used to process and recognize the light spot image, as shown in Fig. 4. The pre-processing of the spot image is shown in Table 1.

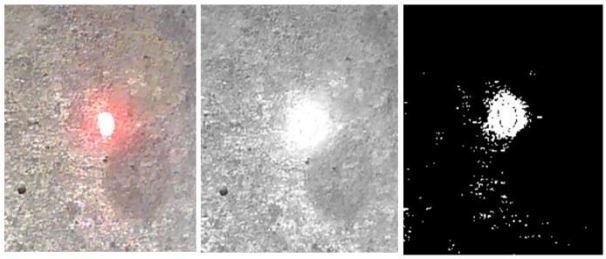

FIG. 4 Speckle image

Table 1 Preprocessing of the spot image

The system operating mode	Edge direction sensor	Forward direction sensor
Don't sweep along the wall; Without corners	Greater than the threshold	Greater than the threshold
Sweep along the wall	Close to the threshold	Greater than the threshold
Sweep along the corner	Close to the threshold	Close to the threshold

In fact, the most difficult part of the whole system for the recognition of various working conditions is the recognition of dim corners that are easy to accumulate dust, such as the bottom of the sofa and bed. Although the above-mentioned sensor can identify the ground material with a high accuracy rate, if it is applied to the bottom of the sofa, bed, and other corners to judge, I am afraid that the accuracy rate of its judgment will be insufficient. The experiment of image processing shows that: the gray sensor still uses a strong light to create light reflection conditions in the dim corner so as to detect gray value will obviously destroy the dark light conditions of itself. Moreover, the obvious disadvantage of this method is that it cannot resist the interference effects of various ambient light. With reflective detection in all directions all the time, energy consumption and user experience will also be reduced.

At present, the NVIDIA image recognition model and engine are used. Compared with the self-trained model, its

resource utilization rate is low, and recognition accuracy is high. The image of the robot after several complete cleaning task cycles is taken to identify the features related to the dark light environment, the bottom of the bed, and the bottom of the sofa in the image so that the recognition ability of the whole model for the blind corner of dark light is greatly improved.

V. CONCLUSION

The blind-corner intelligent cleaning assistant based on the sweeping robot has a relatively lower cost and wide applicability. Through preliminary tests, it can improve the problems of the existing sweeping robots and significantly improve the cleaning ability of the robots. Users get a more comfortable, convenient, and efficient smart home experience.

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