ISSN 2616-5767 Vol.5, Issue 4: 29-33, DOI: 10.25236/AJETS.2022.050406

Research and Design of Intelligent Sweeping Robot Based on Stm32

Jingxiang Pei

School of Telecommunications, Beijing Jiaotong University, Jiaoda East Road, Beixiaguan, Haidian District, Beijing, 100091, China

Abstract: *Design a fully automatic, practical sweeper with automatic route planning, obstacle avoidance, sweeping and vacuuming functions. The STM32 chip is the core control chip for this robot, which is used to read external sensor data and control the normal operation of external devices. The sweeping robot has a modular design, with different design concepts for different modules. Compared with the traditional sweeping robot, robot explored and designed has stronger sweeping ability, fewer dead corners and higher efficiency, which provides design ideas for higher quality sweeping robot.*

Keywords: *Sweeping robot; Singlechip; Multisensor fusion location; Modular design*

1. Introduction

In order to ease the chore of tidying up, keeping homes and offices clean and tidy, and making life easier, sweeping robots have been created. Also known as robot hoovers and intelligent vacuuming, it is an intelligent appliance that has gradually emerged over the past few years, combining cleaning, vacuuming and mopping in one [1].

2. Overall design solution

Using a modular design, the robot is divided into three modules according to its function: the obstacle avoidance module, the travel module and the sweeping module. The sensors such as ultrasonic sensors, infrared sensors and gyroscopes are used to sense the surroundings. The development board based on the stm32 microcontroller can first read the values of these external sensors and then process the data using control algorithms in the software design section to sense the external environment. The processed data is then used as the basis for the control of the travel module, which controls the robot's forward, backward, steering, stopping and rotation. The travel module consists of a McNamee wheel, motors, servos and a carrier mechanism. The sweeping module is relatively isolated from the first two modules and is responsible for sweeping, mopping and vacuuming the floor during travel.

3. Hardware design

3.1. Obstacle avoidance module

3.1.1. Gyroscope

The gyroscope records the yaw, roll and pitch angles. Where the gyroscope is initialized with a yaw angle defined as 0 °. The gyroscope yaw will record the actual yaw direction of the robot during working.

3.1.2. Ranging sensor

Eight ultrasonic sensors are arranged around the sweeping robot to measure the distance between the robot and obstacles, and roughly estimate the size and shape of the house When the distance between the obstacle and the robot is less than one meter, start high-precision laser ranging [2].

3.1.3. UWB positioning

Drawing a map. A UWB base station is placed in the room as the origin and a polar coordinate system is plotted in the system to record the real-time position of the robot in terms of (side length, angle). The map is divided into a matrix of m*n elements, and if the robot sweeps across the matrix, the element at the corresponding position is set to 0. UWB positioning guides the robot to areas that have not been swept or clean dead corners

3.2. Travel module

Servo: constitutes the front wheel steering mechanism, using pulse width modulation (PWM) to achieve steering of the servo angle [3]. Motors: constitute the rear wheel motor drive mechanism, using brushless DC motors to achieve the robot's forward and reverse. McNamee wheels: Use the vector force of each wheel to practice in-situ rotation and other movements. Encoder: Uses gears to engage with the rear wheel motor to accurately measure the motor speed.

3.3. Sweeping module

Peristaltic pump: evens out the water and moistens the floor for easy mopping. Extractor fan: Provide strong suction to the garbage with small volume and light weight such as dust particles. It also includes a mop, broom and waste container.

4. Software design

The of the sweeping robot is mainly based on the PID algorithm, and the feedback value of the external sensor will be used as the basis for the adjustment of the control system. During driving, the distance sensor measures the distance to the obstacle, and the gyroscope records the actual driving direction. When there is deviation in driving, the single chip microcomputer will correct the motor speed, steering gear PWM, etc. according to the set PID coefficient.

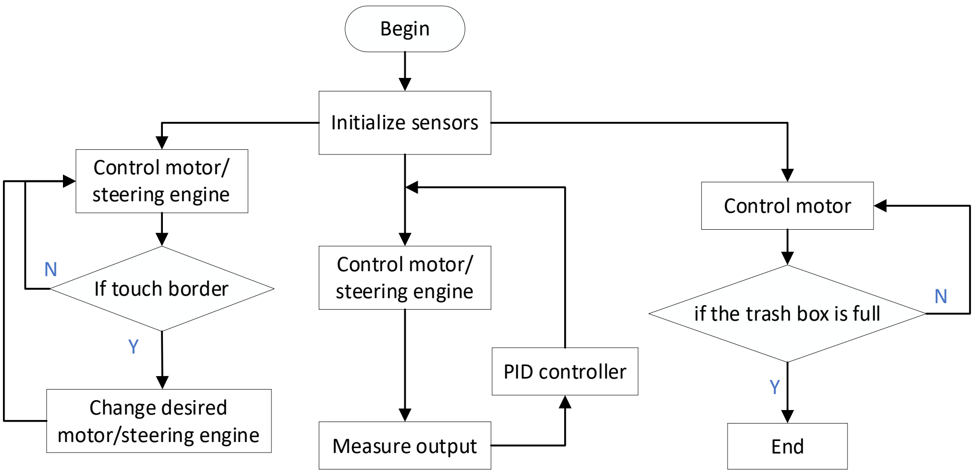


Figure 1: Overall idea of software

4.1. Positioning module

The positioning module uses ranging sensor, gyroscope and UWB for positioning. Initialization is required before work. UWB takes the base station as the origin and establishes the polar coordinate system map. The sensor is used for obstacle avoidance, steering and other functions when moving forward

Using the ultrasonic distance sensor to roughly detect the size and shape of the indoor room, the sweeping robot will give priority to the wall closest to itself to start carpet sweeping. AOA (angle of arrival) positioning in UWB positioning mode is used to divide the map into n*m matrix points. The cleaned points are set to 0, and vice versa. When all matrix points of the room are set to 0, it is deemed that the room cleaning is completed. When facing the wall, the robot preferentially turns to the unclean area and marks the area as an infeasible area on the map.

ISSN 2616-5767 Vol.5, Issue 4: 29-33, DOI: 10.25236/AJETS.2022.050406

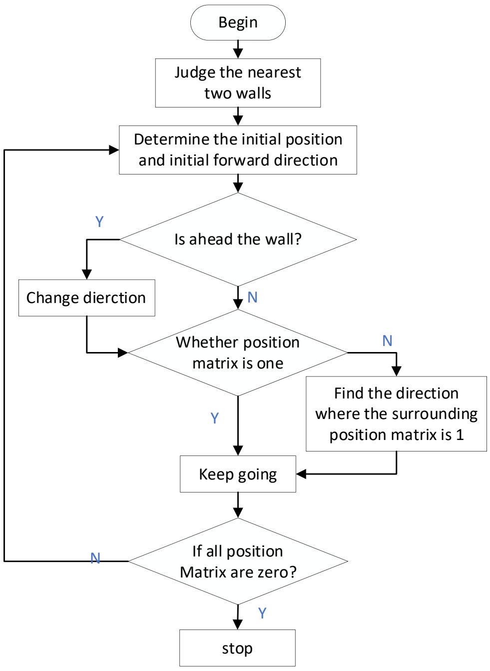


Figure 2: Positioning module logic

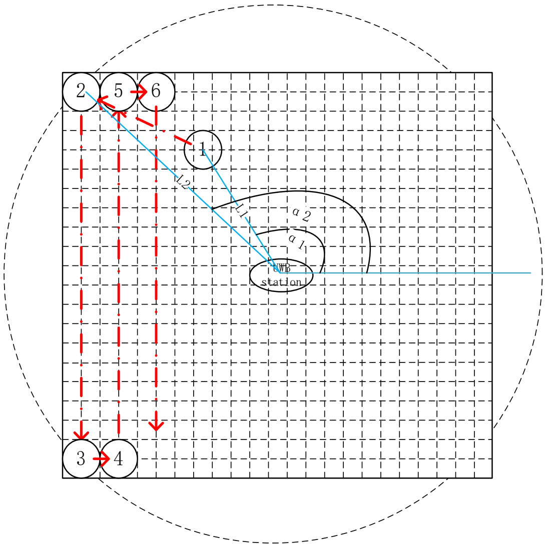


Figure 3: Travel map

4.2. Travel module

4.2.1. Steering or rotation judgment

Travel module comprises a front wheel drive module, a rear wheel drive module, an encoder and Mecanum wheel. The steering mechanism is controlled by the steering gear. When the left and right range sensors detect that the sweeping robot is not running with the wall, the single chip microcomputer modifies the steering gear PWM and modifies the forward direction of the robot. When there is a wall in the front and large curvature steering is required, the sweeping robot stops and uses the Mecanum wheel to rotate in place.

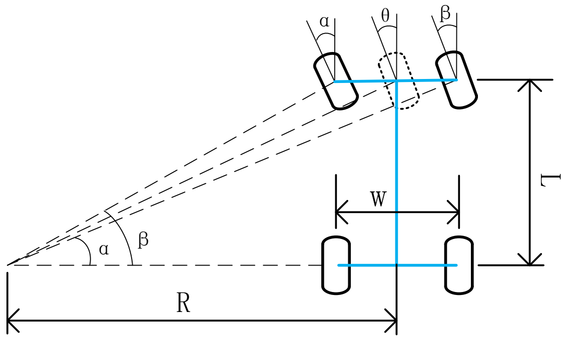


Figure 4: Calculation of maximum turning radius

α is the angle of rotation of the left front wheel relative to the mid-pipeline of the rear wheel and β is the angle of rotation of the right front wheel relative to the mid-pipeline of the rear wheel, then the actual angle of rotation of the sweeper is

$$\theta = \frac{\alpha + \beta}{2}, \alpha < \beta < \alpha + t, 2° < t < 4°$$

Wheelbase is W and the front and rear wheelbase is L, the turning radius of trolley is

$$R = \frac{W}{\sin(\theta)} \tag{1}$$

The minimum steering radius is R. When the required steering curvature is less than the minimum achievable curvature $\frac{1}{R}$, The sweeper will use in-situ rotation for steering.

ISSN 2616-5767 Vol.5, Issue 4: 29-33, DOI: 10.25236/AJETS.2022.050406

4.2.2. PID control of the servo and motor

In order to avoid interference factors such as friction, we use PID algorithm to correct the angle and speed [4]. The actual travel direction is judged according to the AOA mode of UWB and the yaw angle fed back by the gyroscope, and the speed is recognized by the encoder.

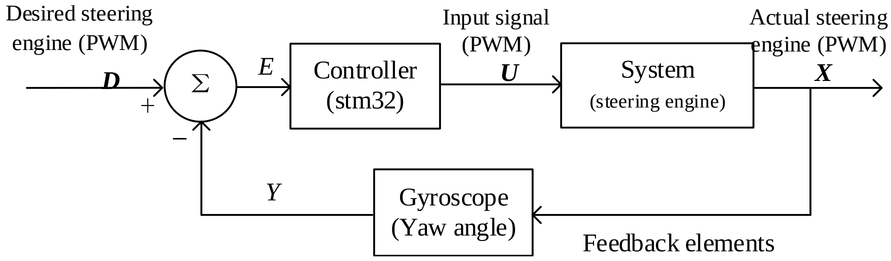


Figure 5: System PID algorithm flow

Suppose the expected value is $D(s)$, the control function of control algorithm is $E(s)$, the control function of the system is $H(s)$, the negative feedback control function is $F(s)$, and the actual signal of the output is $X(s)$, then

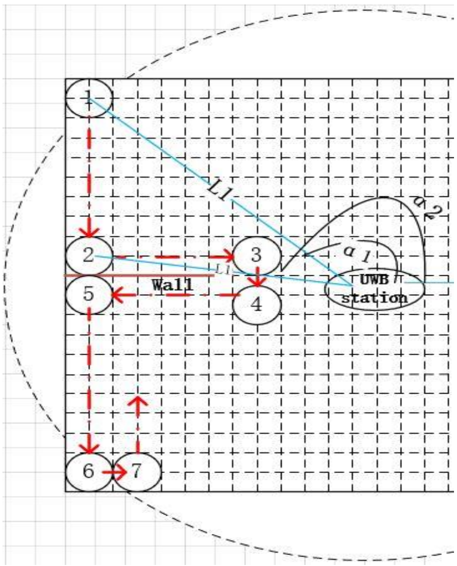
$$E = D - Y, \quad U = C(s) * E, \quad X = H(s) * U, \quad Y = F(s) * X$$

Solve functions, get:

$$X = \frac{C(s)*H(s)}{F(s)+F(s)*C(s)*H(s)} D \tag{2}$$

When the travel angle deviates, adjust the PWM to quickly and accurately correct the direction. When the wheel speed is insufficient, PID is used to adjust the DC voltage of the motor to keep the sweeping robot running at a uniform speed.

4.2.3. Obstacle avoidance when obstacles get in the way



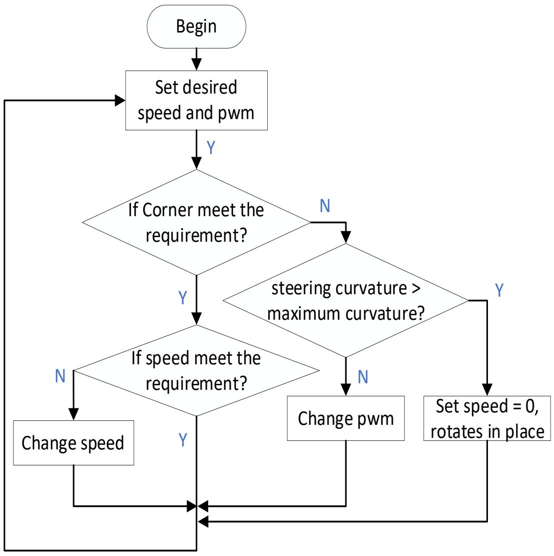


Figure 6: Obstacle Avoidance Map *Figure 7: Corner turning logic*

When the sweeping robot needs to turn sharply when it meets walls and obstacles, it will stop immediately and rotate in place with mcnamu wheel. This effectively avoids parts of the space that cannot be cleared when adjusting the direction of travel [2].

The gyroscope records the roll angle and pitch angle. When the roll angle and pitch angle are greater than 30°, the robot stops immediately, and there is a 'wall' in the area marked on the UWB map. Then the robot rotates in place and continues to clean along the 'wall'. When the ranging sensor detects that it is five centimeters away from the wall, adjust the steering angle. Frequent reading of sensor values will increase the chip pressure, and less reading cycle will cause the robot to have no time to respond [5]. Set the sensor reading cycle to 0.1s after the test.

ISSN 2616-5767 Vol.5, Issue 4: 29-33, DOI: 10.25236/AJETS.2022.050406

5. Concludsion

The core function of the sweeping robot is to clean the garbage with high quality. Therefore, when designing the sweeping robot, the first goal should be to complete the sweeping task. The sweeping robot designed in this paper adopts a variety of sensors and draws indoor map at the same time. When cleaning the whole indoor environment, it takes into account the functions of obstacle avoidance, fall prevention, automatic route planning and so on. The use of map makes the robot no longer roam indoor cleaning, but transformed into carpet step-by-step cleaning. This model can greatly reduce meaningless duplication of work and improve efficiency [6]. At the same time, it can also take into account the corners of. However, the extensive use of sensors, motors and other equipment will increase the power consumption and the volume of the sweeping robot. Moreover, the configuration of UWB base station will also bring some workload. Therefore, it is also necessary to save a set of working procedures of the traditional sweeping robot in the robot to avoid that the sweeping robot cannot work without drawing a map.

References

[1] Xue Xiaou. Design and implementation of intelligent sweeping car based on STM32 [J] Electronic production, 2021 (21): 27-30. DOI: 10.16589/j.cnki.cn11-3571/tn.2021.21. 008.

[2] Wang Jin, Wang Fengtu, Fan Hua, Xue Chao, Yan Kai, Xiang Yu Design and implementation of sweeping robot based on STM32 [J] Foreign electronic measurement technology, 2018, 37(11): 100-103. DOI: 10.19652/j.cnki.femt.1800972.

[3] Wu Penghao, Xu Mengru, dou haopeng, Ge Zhongyi, Wu Baochun Design of sweeping robot based on STM32 single chip microcomputer [J] Intelligent computer and Application, 2019, 9(06): 248-250+253.

[4] Zhang Chizhou, Xiong Genliang, Chen Haichu Design of sweeping robot system based on inertial navigation [J] Piezoelectric and acoustooptic, 2019, 41(06): 885-889.

[5] Zheng Xiaobin, Zhang Qiong Design of intelligent sweeping robot based on STM32 [J] Southern agricultural machinery, 2020, 51(10): 144-145.

[6] Li Hai Design of obstacle avoidance system of intelligent sweeping robot based on STM32 [J] Electronic test, 2018(23): 29-30. DOI: 10.16520/j.cnki.1000-8519.2018.23.0 11.