Design of Automated Guided Vehicle for Conveying Objects

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Abstract: STC90C516RD+microcontroller was chosen as the core controller of AGV. The magnetic line was detected by Hall sensor, the tracking function of AGV is realized, the ultrasonic ranging function was used to avoid obstacles, and the differential steering of the car was realized by using the output PWM wave, after installation and debugging, AGV can basically achieve the requirement of conveying objects.

1. INTRODUCTION
Intelligent robots are taking the place of human beings to accomplish these tasks, and can adapt to different environments, not affected by temperature, humidity and other conditions, and fulfill special tasks in dangerous areas and human beings can not intervene, AGV is one of them. AGV is widely used in factory production, national defense, medical industry, accident search and rescue, geological exploration, scientific research and so on. [1] AGV is mainly used in the enterprise, instead of manual or manual mechanical handling, play the role of automatic sourcing and transportation to the destination.

2. GENERAL PLAN DESIGN
The hardware of AGV mainly includes: MCU, trace module, obstacle avoidance and collision avoidance module, acousto-optic alarm module, display module, DC motor drive module, power steering module, power module and car body. Its overall structure is shown in Figure 1. The system used STC90C516RD, a 8-bit microcontroller produced by STC Company, as the microcontroller to realized the motor driving and steering, as well as the signal processing of electromagnetic tracking and ultrasonic ranging obstacle avoidance alarm.
2.1 Trace Module

There is a sinusoidal current in the center of the feeding path. According to Biot-Savart law, the changing electric field excites the changing magnetic field, and the changing law of the magnetic field is consistent with the electric field. For a steady current $I$, a magnetic field is generated around a straight wire of length $L$. The magnetic induction at point $P$ is as follows:

$$B = \int_0^{\theta_1} \frac{\mu I}{4\pi r} \sin \theta d\theta$$

(1)

In equation (1), $\mu = 4\pi \times 10^7 N/A^2$, and for wireless long DC conductors, where $\theta_1 = 0, \theta_2 = \pi$, there is:

$$B = \frac{\mu I}{4\pi r}$$

(2)

When a coil is wound above an electrified wire, the positive current will cause a change in magnetic flux through the coil loop, and the induced EMF $e$ will be produced in the loop. According to Faraday's law of electromagnetic induction, the magnitude of the induced EMF is proportional to the rate of change of magnetic flux $\Phi$ through the wire loop, that is, the magnitude of the induced EMF is proportional to the rate of change of magnetic flux through the wire loop. That is:

$$e = -\frac{d\Phi}{dt}$$

(3)

If the distance between the center of the coil and the wire is $d$ and the magnetic field distribution is approximately uniform in a small range, the induced EMF in the coil is:

$$e = -\frac{d\Phi}{dt} = \frac{k}{d} \frac{di}{dt}$$

(4)

$k$ is the area of the coil. Formula (4) shows that the magnitude of the induced electromotive force in the coil is proportional to the rate of change of the current and inversely proportional to the distance from the center of the coil to the wire. That is, the closer the inductance is to the live wire, the stronger the inductive electromotive force is, whereas the farther the inductance is from the live wire, the weaker the inductive electromotive force is.

The electromagnetic sensor used in this design is 3144 type Hall sensor. A symmetrical electromagnetic sensor is installed in front of the car. When the car deviates from the electrified wire in the course of automatic driving, the electromagnetic sensor in front of the car will produce inductive electromotive force. Ideally, the electrified wire passes right through the robot's central axis, and the electromagnetic sensors on both sides produce the same inductive electromotive force with the same...
magnitude and direction, the difference being zero. If the car deviates from the direction in the course of driving, the EMF difference will be generated by the electromagnetic sensors on both sides. [3] The EMF difference will be converted into digital signal by AD converter and processed by MCU to adjust its driving direction.

Because the electromotive force directly induced by inductance coil has the characteristics of weak signal and much noise, it is necessary to select frequency, amplify and detect the signal in order to guide the car forward accurately by current magnetic field. The correlation current is shown in Figure 2.

Fig. 2 Circuit of signal processing

2.2 Distance and collision avoidance module
The working principle of system ranging is that the transmitting probe continuously emits 40 kHz ultrasonic wave under the control of single chip microcomputer. When it encounters obstacles, it produces reflected wave, and the receiving probe receives the reflected wave signal and converts it into electric signal.

When the first echo signal is obtained, the time difference between transmitting and receiving is \( \Delta t \), and the distance of obstacle can be calculated according to the \( S = C \cdot \Delta t / 2 \) (\( C \) is the speed of sound). Because the speed of sound in air is related to temperature, if the temperature is constant, the speed of sound will not change. At 0 degrees Celsius, sonic \( C_0 = 331.5 \) m/s. For any temperature \( T \), the speed of sound \( C_i \) will be \( C_i = C_0 + 0.6077T \), that is

\[
C_i = \frac{331.5}{273} + 0.6077T
\]

According to the related literature [5], the sound speed increases about 0.607 m/s with the temperature rising one degree, and the relationship between the sound speed \( C \) and the field temperature \( T \) is obtained as follows:

\[
C = 331.5 + 0.6077T
\]

so:

\[
S = \frac{(331.5 + 0.6077T) \cdot \Delta t}{2}
\]

The temperature \( T \) in the form is measured by the temperature test module (DSB1820). In a very short period of time \( \Delta t' \), the displacement of the truck is \( \Delta S \), in a timely manner:

\[
v = \lim_{\Delta t' \to 0} \frac{\Delta S}{\Delta t'}
\]

The ultrasonic transmitting circuit of this system is mainly composed of reverse 74AHC04 and ultrasonic transducer The receiving circuit adopts integrated circuit CX20106A[4]. After receiving square wave, CX20106A outputs low level to single chip microcomputer. The circuit is shown in Figure 3.
2.3 Design of driving steering circuit

2.3.1 Kinematic analysis
In order to facilitate the kinematics analysis of the car, a coordinate system is first established as shown in Figure 4.
Set up two coordinate systems for the intelligent car. XOY is the world coordinate system, X'PY' is the moving coordinate system of the car, and PX' is the moving direction of the car. At any time, the position and direction of the car in the space, that is, the position of the trolley can be x, y, θ. There are three parameters to represent, where x is the moving component of the car on the X axis, y is the moving component of the car on the Y axis, and θ is the angle between the position of the car at any time and the positive direction of the X axis. The so-called intelligent car differential drive means that the speed of the car's left and right wheels is used to control whether the car is running in a straight line or turning left and right.

Using $v_l$ and $v_r$ to express the speed of the left and right wheels of the car respectively, the calculation formula of the amount of movement of the car in space is as follows:

$$x(t) = \frac{1}{2} \int_0^t [(v_l(t) + v_r(t))\cos(\theta(t))] dt$$  \hspace{1cm} (9)$$

$$y(t) = \frac{1}{2} \int_0^t [(v_l(t) + v_r(t))\sin(\theta(t))] dt$$  \hspace{1cm} (10)$$

$$\theta(t) = \frac{1}{2} \int_0^t [v_l(t) - v_r(t)] dt$$  \hspace{1cm} (11)$$

In equation (11), $l$ is the distance between the two driving wheels of the trolley. The following conclusions can be drawn from the above three formulas: when the speed of the two wheels of the car is equal and the direction is the same, the trajectory of the car is a straight line; when the speed of the two wheels of the car is equal and the direction is opposite, the trajectory of the car is rotated around the origin of the moving coordinate system; when the direction and speed of the two wheels of the car are the same. When the size remains constant and the speed difference remains unchanged, the trajectory of the car is circular.

2.3.2 Driving diagram Circuit

The system uses two speed-down DC motors to control the front wheels and the left and right wheels of the car respectively, corresponding to the four-channel output of L298. Optical coupler TLP521-1 is added between L298 and MCU to completely isolate the interaction between the MCU system and the motor circuit, so as to completely eliminate the influence of motor operation on the system. Its circuit is shown in Figure 5.
2.4 Design of display function
The display module mainly includes three parts: LED indicator display, LED digital tube display and LCD display. The indicator is mainly used to indicate the working state of the truck, which is programmed by users according to their needs. The LED digital tube can be used to display four different speed grades and vehicle operation modes of the moving vehicle. LCD SMC 1602A LCM is mainly used to display the distance from the obstacle, the current speed and ambient temperature of the moving vehicle [6]. Software design.

The software of the system is mainly composed of main program, shoe-avoiding subroutine, tracking subroutine, ranging subroutine, display subroutine, infrared decoding subroutine and delay subroutine, etc.

3. SOFTWARE DESIGN IDEAS
When the control system is powered on, relevant signals will be judged. According to the signal conditions, corresponding controls will be made by the intelligent control program. The general idea of the program is shown in Figure 6.
According to the design idea of the flow chart in Fig. 6, the main program is taken as the main line, and each subroutine is constantly called by the main program according to the level state of the control signal, so as to control the whole running system. The main program main() is as follows:

```c
Void main (void) //main program entry
{
    bit ExeFlag=0; //Define executable bit variables
    Init(); //Initialization function
    while(1) //Program main loop
    {
        if(RL1==0) //Ray judgment
        {
            RightLed=1;
            LeftLed=1;
        }
        else
        {
            RightLed=0;
            LeftLed=0;
        }
    }
    FontIR(); //Obstacle judgement function
    { if(P2^0==0) //Judgement tracking function
    { Xunji(); } //Tracking function
    Csbcj(); //Ultrasonic ranging function
    Display(dis); //Display distance
    Chvast(); } //Speed regulating function
```

Fig.6 Program flow chart
In addition to the subroutine invoked in the main program, the remote signal acquisition program is set in the form of interrupt service subroutine. When P3.3 receives the remote signal, it sends the interrupt request signal to the MCU in time.

4. EXPERIMENTAL ANALYSIS
The experimental prototype is shown in Figure 7.

The experimental prototype is tested. The current temperature, obstacle distance and speed are displayed by LCD. When approaching the obstacle, it can send out the alarm message perfectly and bypass the obstacle or cliff to continue running; If the automatic tracking function is activated, it can drive automatically in the electromagnetic track, with load capacity up to 50Kg, and it also has a good performance in the path with large bending degree.

However, due to the influence of environment temperature and the time taken by operating instructions of Single ChipMicyoco [7], there is a certain deviation between the distance measured and the actual distance, as shown in table 1:

| Actual distance | Detection distance | absolute error | Actual distance | Detection distance | absolute error |
|-----------------|--------------------|----------------|-----------------|--------------------|----------------|
| 20              | 22.2               | 2.2            | 180             | 181.9              | 1.9            |
| 50              | 52.2               | 2.2            | 230             | 231.9              | 1.9            |
| 90              | 92.1               | 2.1            | 270             | 271.8              | 1.8            |
| 130             | 132.0              | 2.0            | 300             | 201.7              | 1.7            |

In order to reduce the distance measurement bias, the linear fitting was adopted to correct the data. In Matlab, the least square method was applied to the linear fitting of first-order polynomial: \( y=ax+b \), the coefficient \( a=0.9983 \) and the coefficient \( b=2.2526 \) were obtained. The modified result is shown in figure 8:
CONCLUSION
To sum up, AGV is a very good hardware platform, and the cost is not expensive, which can be widely used for moving objects in underground mines, automated warehouses, factory workshops and large shopping malls, etc. According to the practical needs of life, some control circuits can be added to complete the task of obstacle avoidance robot, fire fighting robot, transport robot, driverless car and so on. This design has certain popularization and application value.

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