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Design of Intelligent Ultrasonic Guided Vehicle

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ABSTRACT

Due to the requirement of the development of the times, all walks of life require more and more intelligence, so more and more intelligent mobile machines and equipment are popularized. Compared with traditional equipment, smart cars have better mobility, safety and practicality. However, nowadays, domestic follow-up equipment generally exists in various highly specialized venue environments, which have certain environmental requirements, or track following camera cars in other specific sites, which have certain environmental requirements. There is no follow-up equipment or personal products for public places with complex situations, such as supermarkets, airports, railway stations, etc.

This paper designs an intelligent vehicle based on Arduino programming, which is simple and practical, highly modular and highly portable. The smart car with low design cost, simple and mature technology and high portability can be used in work and ordinary life without manual operation. The smart car can use Arduino Nano, acoustic distance measurement module, motor, etc. in this design to achieve the positioning of specific targets and calculate the distance, including forward and backward, turning, At the same time, according to the feedback information, we can adjust the speed and turn behavior to track the target. Using mature ultrasonic ranging technology, chip, accurate positioning control algorithm, this simple, cheap and practical intelligent tracking car is designed.

Key words : Smart car, Ultrasonic, Arduino.

1. INTRODUCTION

At present, most intelligent vehicles have realized some functions required by intelligence, and less consideration is given to their location and transportation. In recent years, many intelligent vehicles have been designed with intelligence and multifunction in mind[1,2]. They have adopted a large number of cutting-edge technologies and become the representative scientific achievements of cutting-edge intelligent technologies, but we have not yet applied their powerful functions and technologies to a wider range of applications. In addition, many traceable products are usually mechanical track type road trackers used for workshop production machinery, or track type road trackers used for competition venues[3,4]. They are not used in public places, such as restaurants, hotels, airports, supermarkets or households. Due to the long-term research and development of intelligent vehicles, the design of autonomous vehicle and the obstacles of autonomous vehicle, the design resources are basically shared, and the technology is relatively mature, providing technical support for the subsequent development of new intelligent vehicles[5]. With the continuous progress of computer technology and the development of automatic control system, the design team has established a trackless adaptive tracking module with ultrasonic and infrared interaction based on the in-depth study of detection and tracking technology, and a car that runs with the owner. The use of intelligent working mode has effectively improved people's working efficiency and met the needs of contemporary social development[6-8].

Today's positioning technology is quite mature, including the Global Positioning System (GPS) and mobile positioning information. At the same time, due to the complexity of the environment, positioning technology has reached its limit. For example, in complex indoor environments, such as supermarkets, airport halls, and mines, it is often necessary to determine the relative location of mobile devices or their owners, facilities, and objects. At present, the use of relatively mature positioning methods is still very limited[9]. Therefore, researchers have proposed certain indoor positioning solutions, such as auxiliary GPS. Now many experts and scientists have proposed many tracking solutions, such as auxiliary GPS, ultrasonic tracking and Bluetooth, but these have certain limitations, because they must be combined with some external devices[10].

2. OVERALL STRUCTURE DESIGN

Use either SI (MKS) or CGS as primary units. (SI units are strongly encouraged.) English units may be used as secondary This design involves ultrasonic sensor (single receiving, single sending) to determine the position and distance of the transmitting source and the trolley. This design is mainly divided into four parts: control module, transmitting source module, ultrasonic receiving module and driving module.

The design takes the emission source as a separate part, and the main part of the emission source is a single emission ultrasonic module, which has a simple structure. When the transmitting ultrasonic starts to work, the acoustic wave mode transmitting module sends data in real time, measures and calculates the distance with the timing time and the propagation speed of the acoustic wave in the air, and at the same time, the receiving ultrasonic module receives the data.

Secondly, the receiving sensor, chip and driver module are taken as a separate whole. When the receiving sensor receives the signal, the data is sent to the chip, which processes the data, judges the position and distance, and sends instructions to the drive module with the L298N drive module as the core, thus controlling the working state of the DC motor. The overall design process is shown in Figure 1.

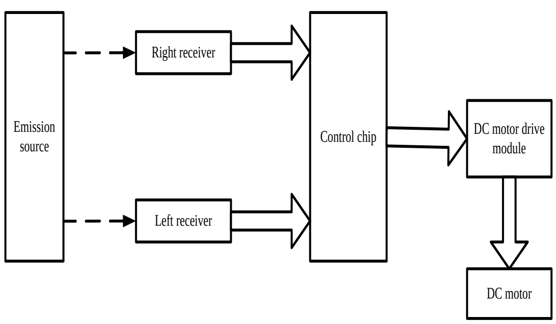

Figure 1: Overall Flow Chart

3. HARDWARE SYSTEM DESIGN

The ultrasonic sensor is composed of a single sending module and a single receiving detection module. The distance data can be obtained by combining the two modules. The single transmitting and single receiving ultrasonic sensor is selected. The transmitting ultrasonic sensor has a transmitting infrared lamp. The transmitting tube transmits infrared signals of a certain frequency. The receiving ultrasonic sensor receives infrared signals of this frequency through its corresponding infrared lamp. The receiving lamp receives infrared signals of this frequency. The transmitting sensor transmits sound waves in real time and is received by the receiving sensor. After processing, the data is sent to the chip through the serial port, So as to realize signal transmission.

When the ultrasonic transmitting module is powered on, it is necessary to align the ultrasonic transmitting module with the ultrasonic receiving module. The ultrasonic transmission will continue to send sound waves to the signal, and the ultrasonic receiving module will automatically receive the ultrasonic transmitted through the ultrasonic module. At this time, the data acquired in the ultrasonic receiving module is data about the distance between the two.

Two separate modules each have four external pins.

The 5V and GND pins of the sensor are used in this design. Pin 1 is the power module, which can supply 3-5 volts, while the voltage of the general lithium battery is 3.7 volts, so the transmission sensor can be connected to a single lithium battery; At the same time, a transformer module can also be connected before power connection to keep the input voltage of the sensor constant. Pin 2 is an extension pin, which is empty. Pin 3 is a signal pin, which controls the transmission state of the transmission sensor. Pin 4 is the ground pin.

The sensor pin description is shown in Table 1 below, and the schematic diagram is shown in Figure 2.

Table 1: Ultrasonic emission pin

Pin No	Name	Notes
1	5V	Power supply 3-5.5V
2	RX	Firmware switching
3	TX	signal
4	GND	Grounding, negative pole of power supply

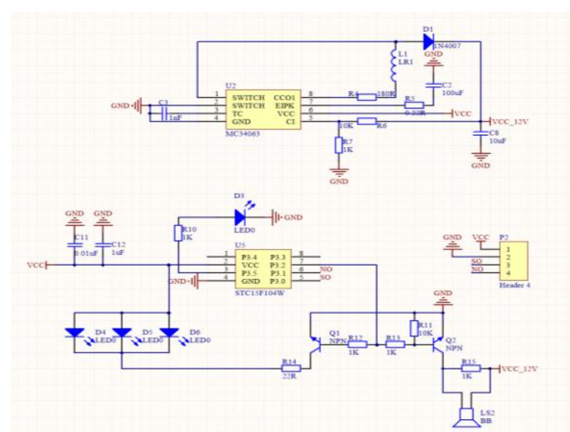

Figure 2: Schematic diagram of ultrasonic emission sensor

3.1 Ultrasonic signal reception

As shown in Figure 3, the receiving sensor uses 5V and GND pins. Pin 1 is the power module, which can supply 3-5 volts, while the voltage of the general lithium battery is 3.7 volts, so the transmission sensor can be connected to a single lithium battery; At the same time, a transformer module can also be connected before power connection to keep the input voltage of the sensor constant. Pin 2 is an extension pin, which is empty. Pin 3 is a signal pin, which controls the transmission state of the transmission sensor. Pin 4 is the ground pin.

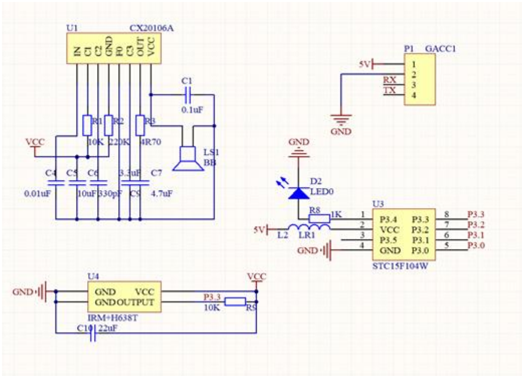

Figure 3: Schematic diagram of ultrasonic receiving sensor

3.2 Emission source

When the ultrasonic transmitting module is powered on, it is necessary to align the ultrasonic transmitting module with the ultrasonic receiving module. The ultrasonic transmission will continue to send sound waves to the signal, and the ultrasonic receiving module will automatically receive the ultrasonic transmitted through the ultrasonic module. At this time, the data acquired in the ultrasonic receiving module is about the transmission distance and the received ultrasonic. The power supply is 3-5 volts, while the voltage of the general lithium battery is 3.7 volts, so the transmission sensor can be connected to a single lithium battery.

3.3 Trolley connection

Connect the receiving sensor, chip and L298N driver module as shown in Figure 3.3. The L298N drive module can drive left and right motors at the same time. This design is a four wheeled car, but also a two wheeled car; The four-wheel trolley only needs to connect the motors on the same side in parallel to realize the forward and turning functions of the trolley.

The connection mode between L298N drive module diagram and control chip is mainly two way connection mode. The motor speed is controlled by PWM pulse width modulation signal. The motor commutation is realized by different input levels on the signal terminal. The input signal IN1 is connected at high level, and the input signal IN2 is connected at low level. The motor 1 reverses. If signal IN1 is connected to low level and IN2 is connected to high level, motor 1 will reverse. The other motor is controlled in the same way. Input signal IN3 is connected at high level, input signal IN4 is connected at low level, and motor 2 runs forward (or vice versa). If the input levels of the two signal terminals are the same, the motor braking function will be realized, that is, the input levels of the two signal terminals are high level or low level at the same time to realize the stop function.

At the same time, it is required to place the receiving ultrasonic sensor at the left and right front ends of the vehicle head, and connect the power supply end, ground end and TX serial port with the signal end of the expansion board. As shown in Figure 4.

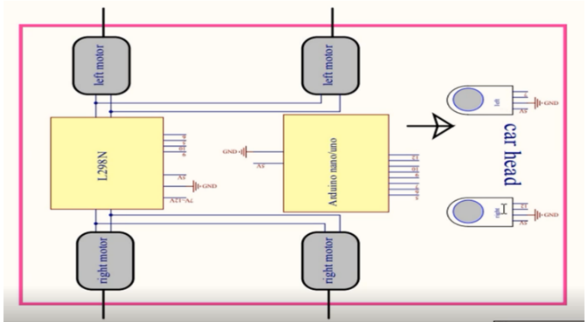

Figure 4: Complete machine trolley

4. SOFTWARE DESIGN

4.1 Software development environment

The programming software used in this design is Arduino IDE, which can realize the programming based on C language, as well as program compilation and program burning. Multiple platforms are supported, and Mac OS, Linux, and Windows operating systems can run normally. The operating system used in this design is Windows.

4.2 System program block diagram

The intelligent following car system in this design is like a human being. The hardware system is equivalent to the human skeleton, and the software system is equivalent to the human brain. The two complement and depend on each other. Only the dominant hardware of the software system can realize the function of the system design. This design uses as the programming language, and is written and compiled in Arduino.

The code of the intelligent following car system includes initialization function, main function control, position distance judgment function, motor driver control code, position error function and speed error function [8]. After receiving the acoustic signal from the transmitting sensor, the receiving sensor sends the data to the chip. The initial distance between the left and right ends is equal. The chip compares the distance data with the initial distance set by the system. If the distance at the left end is greater than the distance at the right end, the car will turn to the right to reduce the distance at the left end so that the distance at the two ends is equal. On the contrary, the distance at the right end is greater than the distance at the left end, Then the trolley will turn to the left to reduce the distance at the right end and make the distance at both ends equal, thus realizing the turning function of the trolley. If the distance between the left and right high ends is equal, the straight-line distance will be compared. If the actual distance is greater than the set initial distance, the car will move in a straight line to track the target source. If the actual distance is less than the set initial distance, the trolley will back in a straight line away from the target source [9], as shown in Figure 5.

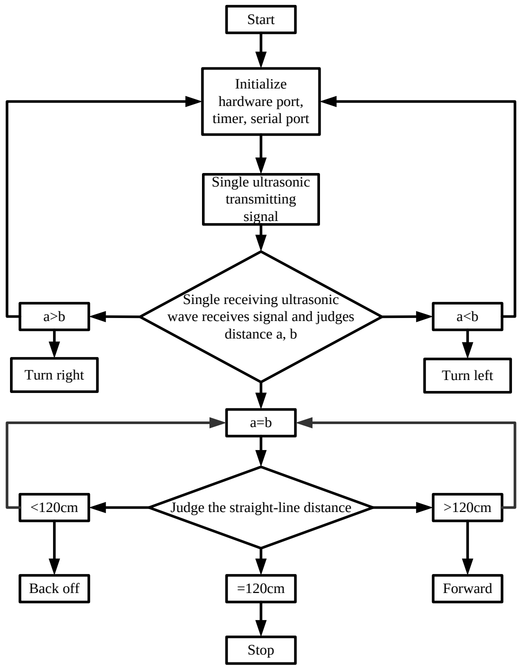

Figure 5: System flow diagram

4.3 Explanation of some codes

4.3.1 Initialization function

Function initialization is to define the pin I/O port mode of Arduino, set the soft serial ports RX and TX for data transmission, and set it as the signal input mode IN PUT according to the purpose, which is used to control the working state of the motor or the signal input mode OUT PUT when the output level is high or low; Initialize the timer and determine the motor pin and the rx serial port of the sensor. The correct data can be received only after the original data of the system is cleared, otherwise the car will not work or will work in an incorrect way if the wrong data is read.

```
#include <SoftwareSerial.h>
SoftwareSerial Serial1(12,13); // Set the soft serial port RX, TX
SoftwareSerial Serial2(7,8); // Set the soft serial port RX, TX
#define leftA_PIN 5
#define leftB_PIN 6
#define righA_PIN 9
#define righB_PIN 10
void setup()
{
  Serial.begin(115200);         // Hardware serial port computer display data
   while(Serial.read()>=0){}     // Clear serial port cache
  Serial1.begin(115200);        // Software serial port receives data
   while(Serial1.read()>=0){}   // Clear serial port cache
  Serial2.begin(115200);        // Software serial port receives data
   while(Serial2.read()>=0){}    // Clear serial port cache
delay(000);
}
```

4.3.2 Receiving data

The single ultrasonic sensor sends signals and the single ultrasonic sensor receives signals. When the trolley is powered on and starts to work, it will directly start to receive the distance, and compare the received distance with the distance set by the system. When the received distance does not meet the set distance, the trolley will receive circularly. Only when the distance that meets the conditions is received, the system will conduct the next data processing, and the trolley will have the next action.

```
void loop()
{
  receive_distance();       // Receive distance data function
  while(left_distance>6000||right_distance>6000)
  {                        //If no data is received, 6800 is received by default. Therefore, if it is greater than or equal to 6800, no data is considered
    motor_stop();        // If no data is received, the trolley stops
    receive_distance();    // Receive again
  }
  motor_control();  // Trolley movement program
  Serial.println();
}
```

4.3.3 Sub function

Sub functions are user-defined functions. Because they are written directly in the main function, and the reading is messy, module functions are written into the sub functions and called in the main function to enhance the readability and clarity of the code. This design is divided into four modules in the sub function part.

One is the distance and position acquisition function: it realizes the real-time detection of the position and distance, and transmits the data to the Arduino motherboard; the other is the drive function: it controls the motion state of the drive module; The third is the position error function: through the analysis of the distance value obtained, the position adjustment is realized, that is, the turning function is realized; The fourth is the speed error control function: use PID to compare the acquired data, convert the position error into the motor speed data, and control the relative distance between the target source and the trolley.

4.3.4 Determination of distance

The principle of ultrasonic ranging is designed based on the propagation speed of sound waves. The time required from the time when the ultrasonic transmitting sensor starts transmitting sound waves to the time when the receiving sensor obtains data is multiplied by the sound speed, so that the distance between the two ultrasonic modules can be obtained from the signal receiving time. The head of the infrared receiver starts receiving data, and the ultrasonic receives data after the stop time. Since the speed of light is much higher than the speed of sound, the time difference is reliable.

Two receiver ultrasonic modules are installed at the left and right sides of the front end of the car, and the target source holds a single transmitter ultrasonic module. In this way, the distance between the person and the two ultrasonic receiving modules can be approximately triangular, as shown in the figure. When the trolley faces people, the distance between the two ultrasonic modules on the trolley is a=b.

When people turn left, a must be less than b.

When people turn right, a must be greater than b.

When people walk forward, the distance between a and b is greater than the set distance. Just determine these distances. Thus, the distance between people and robots and the walking distance of people can be determined to realize the automatic tracking function of robots. The positioning principle is shown in Figure 6.

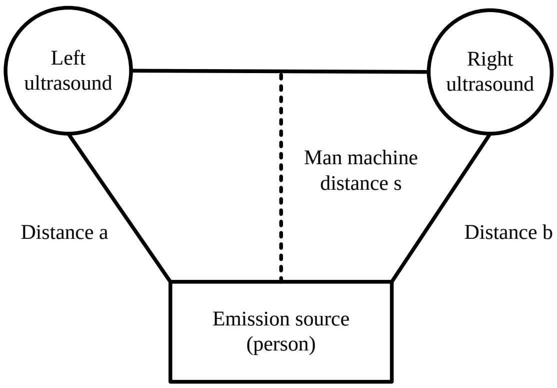

Figure 6: Positioning principle

The speed of the motor varies with the weight of the vehicle body, and the speed of the motor varies with different weights. In order to reduce the error of the motor speed, linear following PID control and steering following PID control are set. Formula (4.1) of PID control is as follows:

$$U_{(t)} = kp(err(t) + \frac{1}{T_t}\int err(t)dt + \frac{T_D derr(t)}{dt}) \quad (4.1)$$

Proportional constant kp;

Integral time constant T_t;

Differential time constant T_D;

In order to keep the following distance and turning stability at a stable value, a linear proportional control and a proportional turning control are set. Under linear proportional control, the target value is set as 1m, that is, the distance that the trolley should travel within 1m. The result is used to adjust the PWM waveform of linear trolley control. The proportional control of turning is the absolute value of the difference between the left and right ultrasonic values multiplied by the proportional coefficient Kp2, which is used to adjust the PWM waveform of the car turning control. The closed loop control of straight line and trolley rotation will improve the reliability of trolley tracking and steering.

5. FUNCTION DEBUGGING AND DISPLAY

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5.1 Function display

The sending ultrasonic module is simple in design and easy to operate. The sending ultrasonic module only needs to be powered on. After the sending ultrasonic module is powered on, the LED on the sending ultrasonic module will flash, which proves that the sending ultrasonic module has been working normally, as shown in Figure 7.

Figure 7: Ultrasonic transmitting module

Receiving ultrasonic module: the principle of ultrasonic ranging is designed based on the propagation speed of sound waves. The time required from the time when the ultrasonic transmitting sensor starts transmitting sound waves to the time when the receiving sensor obtains data multiplies the sound speed, so that the distance between the two ultrasonic modules can be obtained from the time when the signals are received. As shown in Figure 8. The trolley as a whole is shown in Figure 9.

Figure 8: Ultrasonic receiving module

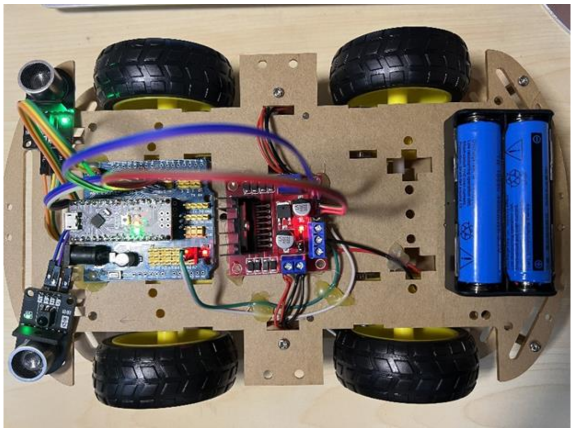

Figure 9: Integral trolley

6. CONCLUSION

After the design and debugging, the system basically achieves the expected function effect. It realizes the human body positioning within the range of 1 meter to 3 meters, can always follow the relative position of the human body of 1 meter, realizes the quick response time of 0.5 seconds when turning left or right, realizes the intelligent tracking function of different positions, and realizes the characteristics of intelligence to a certain extent, and improves and perfects on the basis of summarizing previous designs.

The system basically realizes the functions of detection module, control module and drive module, and meets the needs of intelligent following car and the characteristics of intelligence, system stability, low cost and strong portability. However, some details are not particularly complete. This design only needs some basic functions in the intelligent follow car, and many functions need to be summarized and improved in the actual operation process. According to the needs of the real environment and future development, the following improvements are proposed.

First, multiple sensors can be added to the sensor detection module for all-round detection, so as to approach the real living environment. Second, WiFi modules can be added to send the detected data to the user's mobile phone or other mobile devices through WiFi, which not only facilitates data acquisition, but also enables remote control of the car and remote control of personal mobile devices [10].

The intelligent following car designed in this paper can realize the tracking and positioning of the launch source within the range of 1 meter to 3 meters, and can always maintain a relative position of about 1 meter with the launch source, and can achieve a quick response of 0.5 seconds when turning. The function of intelligent tracking can be realized in different places.

The core part of the following car is to determine the launch source and location and the algorithm of the following core. The transmitter is simple in design and reliable in structure. The position is determined according to a pair of matched ultrasonic sensors with single transmitter and single receiver. Its design uses synchronous timing. The data transmission of ultrasonic and infrared transmitter receives data at the same time, with reliable time difference. Using the basic PID control program, the motor speed changes according to the load. In order to minimize the motor speed error, a linear follower PID control and a directional follower PID control are created.

In the future, we hope to be able to analyze, process and calculate information through collaborative processing. The transport trolley can determine the correct moving route according to the current situation, and transmit the target instructions to the model using wireless communication.

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