Design of Intelligent Saving Robot Based on Six-legged Robot

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Abstract

In recent years, along with the humanity to have high mobility in the complex environment, and high reliability and easy to expand increasingly urgent demand for mobile platform, also the multi legged robot research and algorithm improvement of gait, scientists have considered the research to the application of biped multi legged robot. The motion of the biped robot is confined to the plane, unable to overcome many mountain disaster or rough terrain. Therefore, a rescue robot based on six legged robots is considered. This robot can use mobile phone app to switch robot mode or remote control robot through Bluetooth or wireless mode. And it can be controlled by switch between the automatic and manual mode, and the robot can realize obstacle jumping through sensors to identify the types of obstacles. The robot is loaded with an electronic compass, a camera and a gyroscope, which can intelligently record the path of travel and automatically return to its starting position along the path.

Keywords: Six-legged Robot, Saving robot, Remote Control

1. Introduction

Nowadays, the research on the six legged robot is popular in the world. In addition to the industrial six legged robot is indirectly applied to sorting, most of the six legged robots are only used for entertainment and teaching. Six legged robot with wheeled and tracked robot while showing great advantages in the common way, but in some practical engineering applications, such as disaster relief and rescue, have not appeared the figure of six legged robot. Our most common dance robots are written only through the upper computer, into the action group, and then perform the action group to complete the various dance movements. This robot can only be used for teaching and entertainment, and cannot be applied to practical engineering applications. The robot is in the original dance of the six legged robot based on transformation and special rational design of it and add it to the main control chip, the dance of the six legged robot's mechanical flexibility and a variety of sensors, programming algorithm, which completely turned into intelligent robots, autonomous unmanned control through complex the environment and a variety of additional high-end convenient features to make it more effective to complete the task. Its purpose is to make foot robot can be applied to practical engineering applications, so that it can accomplish rescue, disaster relief and other high-risk work, so as to solve the traditional obstacles such as robots, traffic difficulties and other issues. Through innovation, robots can serve human beings more effectively.

2. The hardware structure design

To better fit the look of the six legged robot, we placed the relevant sensors and hardware modules on a previously designed 15*15 PCB. Multiple modules contact each other and perform their duties. At the same time, we have set aside some blank modules on the basis of independent design, which is convenient for later modification and replacement. Taking into account the limited space inside the robot and the central area, we take the upper and lower double layer design to provide a good environment for the operation of the LCD and GPS modules. The design of the structure is shown in Fig.1.

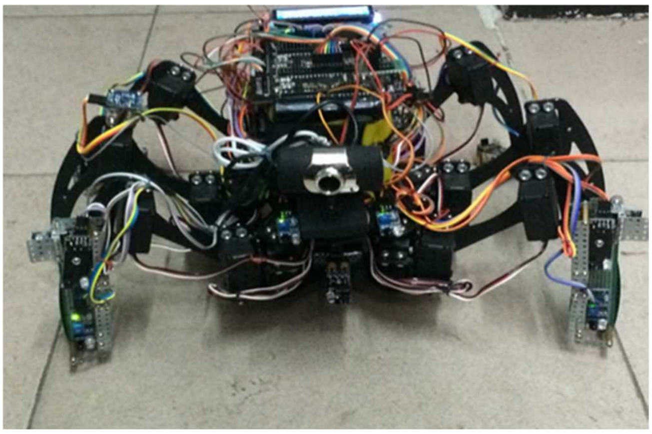

Fig.1 The design of the structure

2.1. Servo control panel

The robot has 18 digital servos, so we have to design a 32-way steering engine panel. The steering engine control panel uses the ATmega16 as the main control. The ATmega16 AVR kernel has a rich instruction set and 32 general-purpose working registers. All registers are directly connected to the arithmetic logic unit (ALU), so that one instruction can access two separate registers simultaneously in one clock cycle. This architecture greatly improves code efficiency and has a data throughput rate of up to 10 times higher than the average CISC microcontroller.

ATmega16 has the following features: 16K bytes of in system programmable (Flash has the ability to read and write at the same time, namely RWW), 512 byte EEPROM and 1K byte SRAM, 32 common I/O port line, 32 general-purpose working registers, JTAG interface for boundary scan, supports on-chip debugging and programming, compared with three the flexible mode of timer / counter (T/C), internal / external interrupt chip, programmable serial USART, serial interface with initial condition detector, 8 Road 10 with selectable differential input stage programmable gain (TQFP package) ADC has an on-chip oscillator Programmable Watchdog Timer, a the SPI serial port, and the six can be selected by the software power saving mode.

2.2. Main control chip

STC12C5A60S2/AD/PWM series microcontroller is a single clock / machine cycle macro crystal technology production (1T) chip is a high speed, low power consumption, strong anti-jamming and a new generation of 8051 single-chip instruction code is fully compatible with the traditional 8051, but the speed is 8-12 times faster. Internal integrated MAX810 dedicated reset circuit, 2 way PWM, 8 way high-speed 10 bit A/D conversion (250K/S), for motor control, strong interference occasions. STC12C5A60S2 has several important characteristics:

- chip integrates 1280 bytes RAM.
- each I/O port drive capacity can reach 20mA, but the whole chip should not exceed 120ma.
- has the EEPROM function.
- There is an independent baud rate generator A/D conversion, 10 bit precision ADC, a total of 8 channels, the conversion speed of up to 250K/S (250 thousand times per second)
- The robot uses independent STC12c5a60s2 microcontrollers, each of which is responsible for the operation of each function of the robot.

The main control chip is shown in Fig.2.

Fig.2. STC12C5A60S2

2.3. L3G4200D three axis digital gyroscope sensor

Simultaneously determine the position of 6 directions, move track, accelerate. A single axis can only measure two directions, that is, a system requires three gyroscopes, and one of the 3 axes can replace the three single axis ones. 3 axis small size, light weight, simple structure, good reliability, is the basic component of the development of laser gyro. The biggest function of the three axis gyroscope is to measure angular velocity to distinguish the motion state of the object, so it is also called motion sensor. Digital three axis gyroscope can support ISP communication and IIC communication. This robot takes IIC communication. And the L3G4200D three axis gyroscope digital characteristics that we found in practical applications to a certain angle gyroscope from a horizontal position, the detected module tilt angle and then to send to the microcontroller module the current location for the starting position, the robot to step provides a convenient. The L3G4200D is shown in Fig.3.

Fig.3. L3G4200D

2.4. GY-271 three axis digital electronic compass

HMC5883L uses anisotropic magnetoresistive (AMR) technology, which has the advantage of being unmatched by other magnetic sensor technologies. The anisotropic sensor has characteristics of high sensitivity and high precision linear axis. Solid phase structure for the orthogonal axis line sensor with low sensitivity can be used to measure the size and direction of the earth's magnetic field, the measurement range from 8 to milli Gauss (Gauss). Honeywell's magnetic sensor is the most sensitive and reliable sensor in the low magnetic field sensor industry. The GY-271 three axis digital electronic compassis shown in Fig.4.

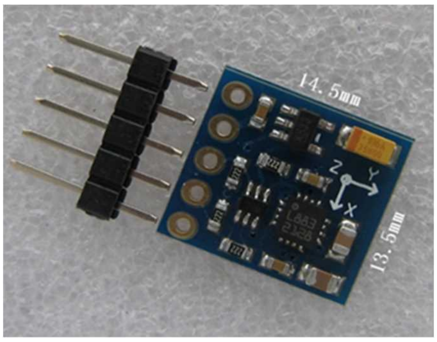

Fig.4. GY-271 three axis digital electronic compass

2.5. HD camera and wireless Bluetooth module

In order to make the robot better with the mobile phone and other mobile terminal communication, we adopt Bluetooth wireless Wi-Fi and 720P HD camera for image acquisition and transmission, the remote control method is more stable than ordinary safe and reliable.

The HD camera and wireless Bluetooth module is shown in Fig.5.

Fig.5.HD camera and wireless Bluetooth module

2.6. Steering engine

The servos are 18 1501 digital servos. Six legged robots with 3 legs each. 1501 metal gear torque, fast speed, low noise, virtual and dead are very small, only need to send a signal to the locking angle, with high control precision, good linearity, in strict accordance with the control protocol, the output angle accurately and fast response and other advantages. At the same time programmable features also make the digital steering gear in dealing with jitter, and offside to more convenient and accurate, slow and more gentle, more smooth, more effective for the motor to provide the torque needed to start. When using servo controller, PC slider index 500~2500 (0.5ms~2.5ms), corresponding to the 1501 digital servo 0~180. The steering engine is shown in Fig.6.

Fig.6. Steering engine

3. System circuit module design

The basic modules of the system include power module, obstacle passing module and route memory module. Through the cooperation of three modules, the basic functions of transmission, obstacle avoidance and route feedback are completed.

3.1. power module design

In order to provide energy effectively, the 5V DC power supply is adopted, and the DC-DC exchange module is shown in Fig.7.

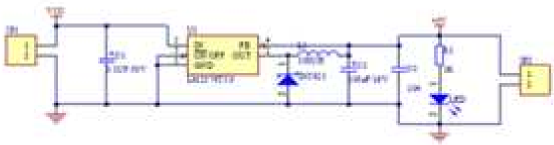

Fig.7. power module design

3.2. Robot obstacle passing module (sensor distribution design)

In order to exercise effective and efficient real-time control and monitoring of the robot, selects the best multiple sensor mounting points, the perfect realization of the linkage and communication module, and ensure the smooth motion. The sensor distribution design is shown in Fig.8.

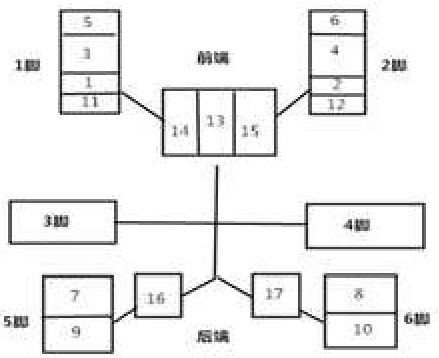

Fig.8. sensor distribution design

3.3. Robot route memory module (electronic compass and gyroscope application design)

In order to accurately measure the route and facilitate the distance when moving, the application of electronic compass and gyroscope is introduced. According to the electronic compass readings, according to a rough estimate of the robot landmark location, although the GPS module including the design of hardware, but the signal is often terrain and object occlusion, leading to the accuracy greatly reduced the effectiveness of GPS signal under complex terrain condition is only 60%. And, in still conditions, the GPS cannot give the heading information. In order to make up for this deficiency, the method of combining electronic compass and GPS for directional navigation is adopted. It can effectively compensate the GPS signal, and ensure that the navigation directional information 100% is effective, even after the GPS signal is lost, the lock can also work normally, and the "lost star" is not lost".

L3G4200D three axis digital gyroscope and master chip communication mode is IIC communication. In any leg of six legged robot gyroscopes in robot leg and lower leg corresponding tilt direction axis has two times the number of changes per two times the number of changes is counted as one step. Then, the robot moves through the main control of the digital gyroscope repeatedly two digital changes step. The combined measurement by directional and pedometer can estimate distance, and the central chip data exchange through WIFI and Bluetooth transmission, real-time display of the completion schedule and tasks can be mobile terminal.

4. Introduction of functional module

In the course of development, the robot has applied some basic scientific principles, and through scientific calculation and adjustment, the machine has been running smoothly and accurately in the plan.

4.1. Robot gait principle

The gait of the six legged walking robot is varied, in which the triangle gait is the typical gait of the six legged walking robot. "Six feet" insects usually do not walk six feet at the same time while walking, but instead divide three pairs of feet into two groups, alternating with a triangular support structure.

At present, most of the six legged robot adopts the structure of insects, 6 legs distributed on both sides of the body, front and rear foot and the right side of the body on the left side of the foot as a group, before and after the left foot and right midfoot for another group, were composed of two triangular bracket, rely on the leg before and after the implementation of paddling support and swing, this is a typical triangle gait, as shown in figure. In the diagram, the robot hip moves horizontally and vertically. At this point, B, D, F feet swing feet, A, C, and E feet do not move, just support the body forward.

Because the body gravity center is low, not coordinated Z movement, easy stability, so this walking program can be widely used. The Sketch map of triangle gait is shown in Fig.9.

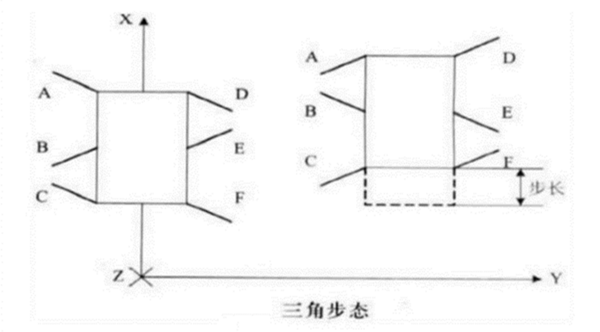

Fig.9. Sketch map of triangle gait

4.2. Azimuth calculation of electronic compass

When the 3 axis magnetometer work can read XYZ three axis magnetic field intensity, and cannot directly used for numerical calculation of azimuth angle, because the readings may be some other devices layout containing magnetic materials, the formation of hard iron drift coordinates, as shown in the following figures. The Azimuth calculation of electronic compass is shown in Fig.10 and Fig.11.

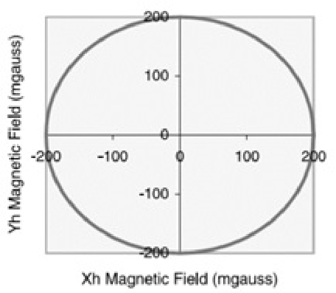

Fig.10. Xh-Yh Figure

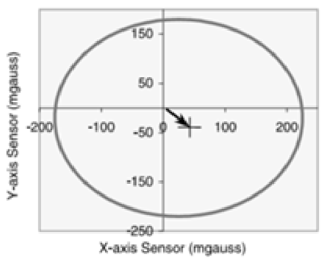

Fig.11. X-Y Figure

The XYZ value used for azimuth calculation must remove the drift value so that the center of the circle returns to the origin. The specific method is: the level of uniform rotation, XY axis rotation data collection equipment, 90 degrees (at the level of Z axis Z axis) uniform rotation to collect data, the data is read into the shaft of the maximum value and minimum value by 2, you get a offset value of each axis.

$$Xoffset=(Xmax+Xmin)/2$$
$$Yoffset=(Ymax+Ymin)/2$$
$$Zoffset=(Zmax+Zmin)/2$$

Then, the naked values of each axis read by the magnetometer subtract the offset value calculated previously, and the Heading values used for angle calculation can be obtained

If only horizontal measurements are used, azimuth =arctanYH/XH. If our device is not in a horizontal position at the time of measurement, the azimuth of the compass will deviate when the above formula is applied, and then the acceleration sensor will be used to compensate the tilt angle of the magnetometer. As shown.

To compensate for the inclination of the electronic compass, the roll angle (theta) Roll and pitch angle (Pitch) must be calculated first .Enter the following formula and calculate the Heading value.

$$Xh=X*\cos(\varphi)+Y*\sin(\theta)*\sin(\varphi)-Z*\cos(\theta)*\sin(\varphi)$$
$$Yh=Y*\cos(\theta)+Z*\sin(\theta)$$

Considering the 4 quadrants of the angle, the formula of the heading angle can be changed into the following formula.

$$for(Xh<0)=180-[\arctan(Yh/Xh)*180/\pi]$$
$$for(Xh>0,Yh<0)=-[\arctan(Yh/Xh)*180/\pi]$$
$$for(Xh>0,Yh>0)=360-\arctan(Yh/Xh)*180/\pi$$
$$for(Xh=0,Yh<0)=90$$
$$for(Xh=0,Yh>0)=270$$

5. Testing and conclusion

The robot can achieve the following main functions in the actual test: the robot can pass all kinds of obstacles, such as self-climbing, stiles, obstacle avoidance, obstacle etc. We can switch to the man-machine control mode, and the operator can use the mobile phone APP to control the robot wirelessly.

The robot also has a one-button automatic return function, and the controller automatically returns to the point of departure by simply pressing the automatic return key. In the design process, the test was moved outdoors, in the natural environment as the experimental site, the environment obstacle robot testing in the outdoor space of this complex capacity, if the robot should be applied to the engineering practice, the robot should be able to adapt to the requirements of the design environment.

The actual error under the design of subtle errors and hardware, the robot automatically return to the starting point of the position deviation distance error is sometimes not the expected range, and the distance coefficient of nonlinear proportional distance error with the robot walking in the actual test for an average of 0.0112. The deflection error is within the range of 4 to 20 degrees.

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