Design and Acceleration of Humanoid Robot Controlled by Stm32

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Abstract. With the development of the industrial internet, the comprehensive application of big data, the internet of things and artificial intelligence are becoming quietly extensive, and they connect physical things to the digital world tightly. Being smart and intelligent has become one of the most important directions of future social development. As an agent, robots will be widely utilized in every corner of society, and the robot era has come quietly.

This paper mainly studies how to let the robot walk according to the prescribed route as a person. Our innovation points are as follows: Firstly, compared with the traditional packaging robot, the steering gear of the legs is similar to that of normal people, and the hands, arms, and heads can also cooperate in the march, just like normal people. Tracking, individual turns, and special gestures can be achieved. Under the combined action of the threshold, CCD, sensor, and 12 steering gear, the robot can complete the patrol walk at a fast speed.

Keywords: Humanoid Robot, Single-Chip, Sensor, Velocity

1. Introduction

1.1. The Development of Robots

With the development of science and technology and the advent of the Internet of Things era, robots have gradually become one of the focus of people's attention. The origin of robots can be traced back to a science fiction novel. A few decades later, robots have been everywhere in human life [1].

According to different uses, robots can be divided into different categories. The humanoid robot has attracted much attention because of its very similar structure to the human body. It can complete various expected tasks through programming, and has the advantages of both human and machine in structure and performance, especially reflecting human intelligence and adaptability. The manipulator can also accurately complete the operation in various environments. Now he is widely used in medical treatment, service, teaching, entertainment, and other aspects, and has broad development prospects in various fields of the national economy [3].
1.2. Development Status of Humanoid Robot

The study of the biped robot can be traced back to the 1980s, and there are many systematic modeling methods and control theories. According to different degrees of freedom, many valuable views and methods have been put forward. After World War II, robot technology in the United States was vigorously developed, with improved manufacturing technology and rapid economic development, while robots were thanks a lot.; In Europe, the European Union launched the "SPARC" research and development program, which has invested 2.8 billion euros and created 240,000 jobs; Japan is using robots as an important tool for future economic development, which can promote a larger range of social and economic improvements; South Korea is also vigorously developing the robot industry and selling robots to overseas markets, promoting the growth of the robot industry [2].

At present, the countries that have the most important influence on the development of robot technology are Japan and the United States. The United States is still in the leading position in the comprehensive level of robot technology [5]. Core robot components produced by Japan and South Korea, such as servo motors, reducers, and drives, are also exported to various Asian countries in large quantities, while the number and types of robots produced in Japan rank first in the world [4].

1.3. Research Hotspots and Issues

Compared with mature industrial robots, humanoid robots appear more frequently in universities or research institutes because of their interest and competitive ability, as described in this paper. The design and debugging of robots involve multiple disciplines, which require a variety of knowledge and abilities, essential, such as drawing, welding, and assembly of electronic components, 3D printing, laser cutting, and programming, which can greatly improve the creativity, practical ability, and comprehensive quality of college students.

Therefore, in the process of making and debugging robots, we have several major difficulties to be solved:

1) The body structure of the robot. We need to be clear about how to match various parts, not only to consider the choice of connection structure, the distribution of freedom. Also must take into account the force analysis, can move steadily. At the same time, I want to be as beautiful as possible.

2) Hardware selection, welding, and protection. To make the real thing, we must first have hardware support, how to choose the rudder model, how much capacity the battery needs, how to design the circuit board and so on all need to be investigated and studied.

3) Software writing. After the hardware is assembled, the program is written and debugged. How can the robot walk like a person by controlling the rotation of each steering gear, turn left and right, and complete the goal of finding a line through sensors.

2. Overall System Design

2.1. Shape Design and Assembly of Related Hardware Equipment

The robot consists of four parts: support structure module, sensor detection module, control module, and power supply module. The first step is to accurately assemble each part to test whether its functions can be completed normally. For beauty, we used ProductView Express to draw three-dimensional pictures of the robot's head and arms and 3D printed them.

2.2. Robot Motion Debugging

To realize the circular tracking of the robot, it can be adjusted by three actions: straight walk left turn, and right turn. Every movement, we will first pursue stability, not to figure fast and the center of gravity instability, the body back and forth shaking situation, based on stability slowly improve the speed.

How to ensure the stability and consistency of robot walking is one of our innovation points. We do not try purely, but use the combination of theoretical analysis and practice, with the straight walk as
the benchmark, left and right turn is based on the straight walk, through the change of individual steering gear to achieve.

2.3. Patrol Line
This part is the sensor control module, which requires the CCD and control, circuit board. By writing code, the information exchange between sensors and robots can be realized. By adjusting the threshold, the robot can walk along the black route accurately.

3. Mechanical Structure Design

3.1. Summary
Design from the purpose, the humanoid racing robot has to be stable and fast, so our mechanical structure design is based on the three concepts of lightweight, strong, and beautiful.

The mechanical structure of the robot is complex, and it takes a long time from the initial design machinery to the final processing. The overall bracket is made of hard aluminum alloy with a thickness of 1mm. This material is not only light in weight but also has large strength. While reducing the weight, the pressure between the leg steering gear is smaller, which is conducive to the durability of the whole system.

In the processing process, we should not only consider the cooperation between each part but also consider the influence degree of each part on the whole robot in the walking process. Because the tightening degree of a screw and a little deviation of the soleplate will affect the walking of the whole robot, the design and assembly of the mechanical structure are more important [6].

3.2. Head and Arm Design
The head design mainly considers beauty and lightness, so we choose to draw a three-dimensional picture of the robot's head with ProductView Express, and use 3D printing technology to print the head model.

The arm must be symmetrical and light, and at the same time ensure the stability of the steering gear installation, so as not to affect the normal walking of the robot due to its large moment of inertia when swinging.

3.3. Leg Design
The leg is the key to the normal walking of the robot, so it is also the most core and important part of the mechanical structure design of the robot. The legs must be strong and flexible, which requires material strength, stability, and freedom of the rudder. We refer to the human leg structure and place a steering gear at the waist, crotch, and knee, and two at the ankle.

Figure 1. The overview of our robot
4. Software Design

4.1. MCU Software

The robot uses an allentekministm32 single-chip microcomputer as the processing center of sensor data, and to reduce the weight to increase the flexibility of the robot and the stability of walking, the smallest system board is used.

When we write robot programs, we use Keil mainly because: Firstly, the target code generated by Keil is very efficient, and the assembly code generated by most statements is very compact and easy to understand. It can better reflect the advantages of high-level languages when developing large-scale software. Secondly, Keil is mainly written in C language. Compared with assembly, C language has obvious advantages in function, structure, readability, and maintainability, so it is easy to learn and use. After using assembly language to develop using C, the experience will be more profound.

In terms of specific function realization, we mainly use CCD to collect track information and perform analog-to-digital conversion through ADC to realize the corresponding output of a single-chip microcomputer to control the control board [8].

The STM32F103 series have at least 2 ADCs. The STM32F103RCT we chose contains 3 ADCs. The maximum conversion rate of STM32 ADC is 1Mhz, that is, the conversion time is 1us (obtained under ADCCLK=14M, and the sampling period is 1.5 ADC clocks). Do not let the ADC clock exceed 14M, otherwise, the accuracy of the result will decrease.

You need to configure the ADC registers, configure them as analog input pins, reset all registers of the peripheral ADC1 to default values, ADC1 and ADC2 work in independent mode, and analog-to-digital conversion work in single-channel mode and single conversion mode. The conversion mode is software trigger, and the data is right-aligned. After each register of ADC is configured, we can execute the mode we need to complete the established function. The robot is recognized by the CCD at different positions on the track, and the ADC converts the brightness signal transmitted by the CCD into the corresponding value. By matching this value with the interval set in the program, it can output
signals in different voltage intervals to control the robot. The main control board controls the robot attitude mode [7].

4.2. Motion Design Software
The robot realizes the control of each steering gear through the main control panel, and the programming of the main control panel and the rotation data debugging of each steering gear is realized by the software RoboPlus.

Edit the servos with the corresponding numbers in the software and adjust the joint values to adjust the motion amplitude and speed of different servos in different steps. After constant trial and error, you can find the right value to make the robot move quickly with the appropriate stride and speed. Through further numerical adjustment, the steering gear can be controlled to change the center of gravity of the robot to complete the turning action. And through the software, RoboPlus Task can save the action, and through programming in the software to implement different actions under different input conditions, to achieve the robot attitude response to the control data sent after the microcontroller recognizes the data collected by the CCD [9].

Table 1. A numerical value of each steering gear of a robot when walking straight

| Steering gear number | Stand | Step 1 | Step 2 | Step 3 | Step 4 | Step 5 | Step 6 |
|----------------------|-------|--------|--------|--------|--------|--------|--------|
| 7                    | 512   | 512    | 512    | 512    | 512    | 512    | 512    |
| 8                    | 512   | 510    | 507    | 510    | 512    | 512    | 512    |
| 11                   | 655   | 650    | 645    | 632    | 662    | 681    | 691    |
| 12                   | 369   | 365    | 346    | 336    | 374    | 379    | 392    |
| 13                   | 763   | 737    | 755    | 773    | 791    | 773    | 755    |
| 14                   | 261   | 233    | 251    | 269    | 287    | 269    | 251    |
| 15                   | 637   | 630    | 630    | 630    | 653    | 653    | 653    |
| 16                   | 387   | 371    | 371    | 371    | 394    | 394    | 394    |
| 17                   | 512   | 512    | 512    | 512    | 512    | 512    | 512    |
| 18                   | 508   | 508    | 508    | 508    | 508    | 508    | 508    |

5. System Development and Debugging

5.1. Robot Walking
We use RoboPlus software to debug the action to achieve the initial straight-walk action and turn. In addition to the numerical adjustment, we utilize the human body's personal experience, simulation to get the best posture. Control of the center of gravity is the most important, only rely on the late sensor control is difficult to achieve, so we through the physical, algorithm method, good control before and after the robot, swing range, lift foot height, and then gradually increase the speed, increase the difficulty of the track, later gradually realized the effect of very stable, can complete in the case of high speed, run completely.

To sum up, our plans include:
(1) Reduce the actuating speed of the steering gear and ensure its stable walking first.
(2) Shooting video in slow motion, because we often find that the robot has the problem of lateral drift, for this reason, we need to watch carefully, find out the problem, ensure that the foot does not appear in the case of the slow movement, steadily lift, fall.
(3) Control battery voltage, it is the center of gravity position, etc. At first, there was no fixed battery position, and a strange phenomenon appeared: without changing the program, the robot was allowed to walk in a straight line twice in a row, one to the left and one to the right. When we got into
a bottleneck, we suddenly found that the robot battery was not fixed tightly, and the battery would move a little after walking down. To this end, I can mark the battery and tighten the fixed, solve this problem.

(4) The radius of the left turn is slightly smaller than the radius of the track, which can not only control the total length of the path but also reduce the number of right turns, to keep the robot running well.

5.2. Robot Tracking

The CCD sensor is a new photoelectric conversion device, which produces signal charge after being stimulated by light intensity. When a specific timing pulse is applied to it, the stored signal charge can be directionally transferred in a CCD, thus realizing self-scanning. It mainly consists of the photosensitive unit, input structure, and output structure. It has the functions of photoelectric conversion, information storage, and delay, and has high integration and low power consumption. It has been widely used in the three fields of the camera, signal processing, and storage, especially in the application of image sensor has achieved impressive development [10].

In use, CCD can be connected with a single-chip microcomputer, and ADC can collect the brightness of 128 points on the line scanned by CCD and convert it into a voltage value. Based on the CCD principle, the idea of finding lines is to adopt negative feedback adjustment to collect the gray value of the innermost black line, so that the robot can walk along the innermost line all the time. Once it deviates, it will perform the reverse action to return to the position of the black line. Through linear CCD, the robot realizes the perception of the track. CCD connected with MCU converts visual information into voltage value (black line < white line), and a curve with trough appears on the computer screen. When the black line trough touches the indicator set by the single-chip microcomputer, the pin outputs the corresponding voltage of 1.6 v, 3.2 v, and 0 v (turn left, right and go straight), to control the robot as an electrical signal. Thinking in the straight walk will not appear problems, but in the corner, there is a probability of losing the line, the robot from the outside out of the track. Finally, we found that we need to change the gray value, and synchronously adjust the action can solve this problem [11].

5.3. Combination of Tracking Signal and Robot Controller.

We select the RoboPlus Task to realize it. The corresponding voltage value of MCU is output to the controller. in the controller, we input the corresponding program of straight left and right turn in advance, and the controller sends out the instruction of which action by identifying the voltage value. However, the acquisition of electrical signals is carried out in real-time. with the same period (delay), the interval between the two movements is as short as possible without affecting the walking of the robot (which may cause the action to be impossible).

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