Design of a Humanoid Dance Robot for Dancing Baduanjin

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Abstract

This paper introduces a humanoid robot which consists of 16 servo motors driving joint and adopts STM32 as the main control chip and dual mode Bluetooth4.0 BLE+EDR wireless control.by programming, the motor of humanoid robot can reach the specified space position and attitude at the specified time. At the same time, digital closed-loop control PID algorithm and synchronous compensation algorithm are used to modify and optimize the Angle of the servo motor in real time, and the designed action is vividly displayed.

Keywords: Humanoid robot, STM32, PID, Baduanjin

1. Introduction

Baduanjin is a traditional fitness qigong in China. Whether from the perspective of traditional Chinese medicine, or from the successful experience of many makeshift hospitals in Wuhan in the rehabilitation of COVID-19 patients, it has been shown that regular practice of Baduanjin can enhance the lung and respiratory function and enhance the body's resistance. To a certain extent, help COVID-19 patients restore their lung breathing function.

At present, the COVID-19 prevention situation is still very serious around the world. Using robots instead of medical staff to guide patients to practice Baduanjin on a regular basis can effectively reduce the risk of infection of medical staff and help patients recover their lung breathing function[1].

This paper introduces a humanoid robot which is composed of 16 servo motors, and uses STM32 as the main control chip and dual mode Bluetooth4.0BLE+EDR wireless control. [1]Through the coordination of the upper computer and the lower computer, the motor of the humanoid dancing robot can reach the specified space position and posture at the specified time. At the same time, digital PID algorithm and synchronous compensation algorithm are used to correct the servo motor Angle in real time, so that baduanjin can be vividly displayed and make an important contribution to the world's fight against COVID-19.

2. System Overview

The device is a humanoid dancing robot combined with artificial intelligence technology. The robot can dance independently according to the choreography. Humanoid dance

The robot's voice recognition and processing and big data processing technology are integrated. Through self-designed PCB, its distributed framework can build Bluetooth communication module, motor drive module and so on.It can realize three characteristic functions: first, it can imitate human dances, and realize the choreography of various dances based on different kinds of dances. At the same time, it can set the duration, so that people of all ages can enjoy the performance

better;Second, the independent dance, cooperate with each other based on the upper machine and lower machine can make better humanoid robot to dance dance choreography and start and stop, without human intervention in the process of dancing can complete set a good time dancing, at the same time we have already set some dance as human-computer interaction reference is more intelligent and strong entertaining;Thirdly, Bluetooth interaction. Based on the existence of Bluetooth communication module, our mobile phones can also control the start and stop of the robot, and see the status of the robot as well as the choreography of the dance, which can realize edutainment and fun, and better and more convenient to learn dance movements.

3. The hardware structure design

The core of the robot is the combination of upper and lower machines, and the PID algorithm makes the Angle and speed of the servo motor more accurate.The hardware is composed of self-designed PCB, Bluetooth communication module, servo motor, 2200mAh lithium battery, encoder and so on.The encoder is installed on the servo motor, used to calculate the rotation Angle of the servo motor, and determine the rotation Angle from the mechanical structure, software program, upper and lower machine control;The driving part is combined with the main control on a PCB, which can make the wiring simple, not messy, and better observe the action of each joint of the robot, to achieve independent movement;The Bluetooth module can display the robot's status on the phone, and the phone can also control the robot's start and stop.

3.1. *Shell modeling part*

The structure of humanoid dancing robot is mainly divided into three parts: upper body, waist and lower body.The upper body is mainly composed of the head, shoulders and arms. The head is made of a white ABS material, and the shoulders and arms are composed of 6 servo motors. The shoulders and arms can be turned 180 degrees to complete relatively difficult movements. The waist is mainly composed of two servo motors, which can make the waist stronger and have stronger flexibility. The lower body consists mainly of legs and feet, connected by eight servomotors, which can support the weight of the

whole body.Can complete the splits, high legs and other difficult movements, better personification.The robot shell material is mainly made of ABS plastic material and aluminum alloy. Because the dancing robot needs to have good anti-fall ability, the combination of ABS plastic material and aluminum alloy is not easy to deform after heavy fall.The battery and PCB are fixed on ABS plastic material so that the PCB and battery are not easy to fall off and play a protective role.Fig.1.shows the full picture of the humanoid dancing robot.
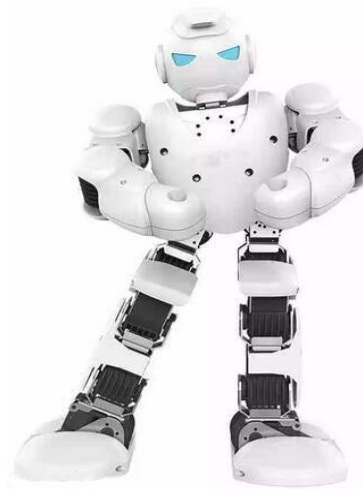

Fig.1. Full view of dancing robot

3.2. *Design of PCB*

It includes the main control part, power module, motor drive voltage regulator module, Bluetooth module.The core chip of dancing robot is single chip microcomputer STM32f103.This microcontroller is used as the main control. Compared with other microcontrollers, STM32 series has high performance, low cost, low power consumption of embedded applications, specially designed ARM Cortex-M3 kernel. According to these advantages, STM32 is used as the core of the robot to design the schematic diagram and printed circuit board. Fig.2. shows the schematic diagram of the main control part.
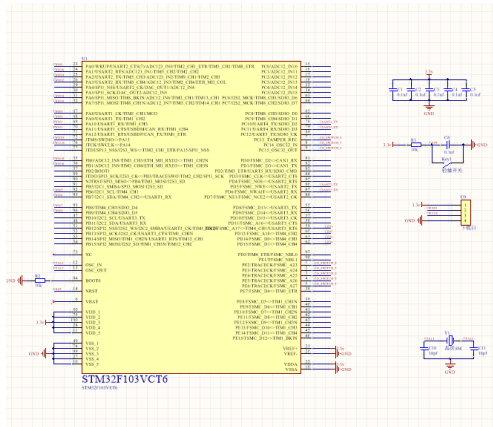
Fig.2. Schematic diagram of main control circuit

The power module adopts 2200MAh lithium battery, which has small internal resistance, large capacity, more cycles and no memory effect. Internal protection design, can prevent charging time is too long, excessive discharge, instantaneous current is too large damage, because the protection of the battery shell will not be more serious impact, can increase the battery life, so that the dancing robot can continue to dance for 2 hours.Fig.3.shows the schematic diagram of the power module.
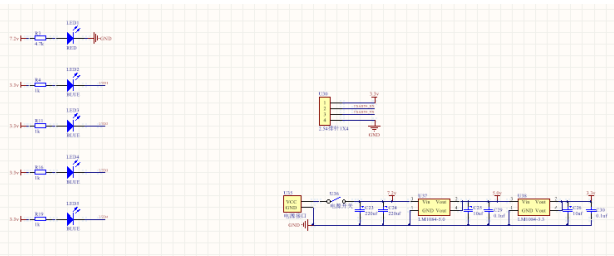

Fig.3. Power supply The power supply circuit

Motor drive voltage regulator module is mainly composed of voltage regulator chip, pin row and bus driver chip, bus driver chip using 74LVC245.Fig.4.shows the function block diagram of 74LVC245.
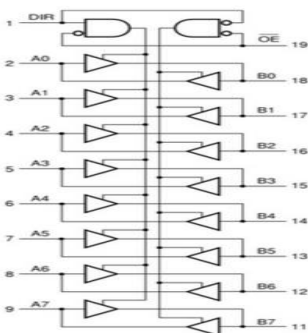

Fig.4. Block diagram of display functions for 74LVC245

Voltage regulator chip we use MIC29302A, stable output, large input voltage range, can better adapt to our servo motor.Fig.5.shows the principle diagram of the voltage regulator driven by the motor.
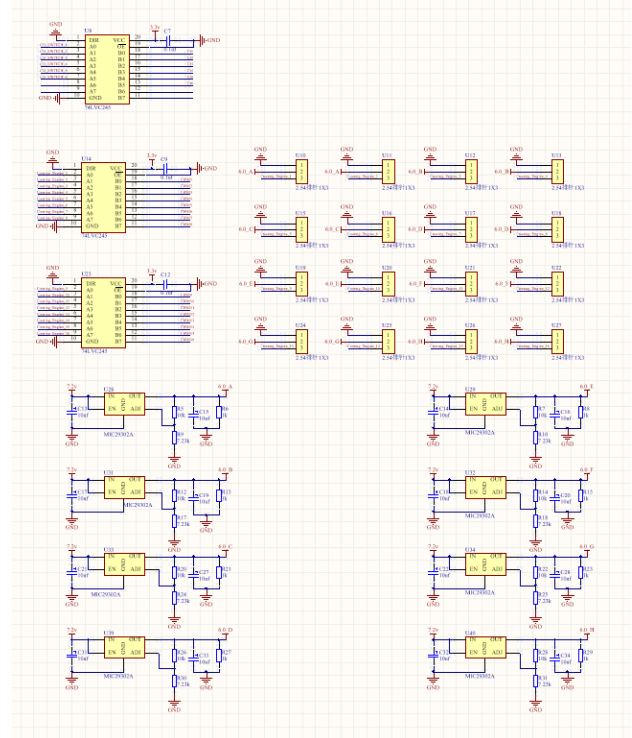

Fig.5. Motor driving voltage regulator module

Bluetooth module adopts bluetooth 4.0BLE +EDR dual-mode Bluetooth control this Bluetooth has many advantages:

- Fast transmission speed
- Low frequency modulation, strong anti-interference
- It is only woken up when execution requires it Low latency
- Wide connection range
- High security

Not only can the robot dance autonomously, it can also start and stop the robot via Bluetooth, which can be both entertaining and addictive. This is the schematic diagram of our Bluetooth module as shown in Fig.6.
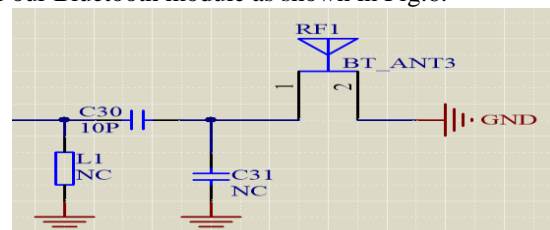

Fig.6.Schematic diagram of the Bluetooth module

3.3. *Cartesian spatial position control of humanoid dancing robot*

We independently design of humanoid robot dance by PCB design control motor rotation, for robots, position control is the precondition of motion control, and need in a certain period of time make the joint to the specified location, position control includes two aspects, respectively is two aspects of the cartesian space and joint space position control. Cartesian open loop control is shown in Fig.7.
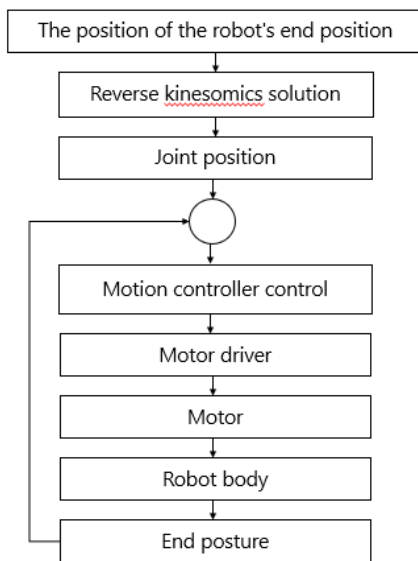

Fig.7.Cartesian open loop control

The problem of the robot's end pose was solved by inverse kinematics, and the coordinate of the end joint in cartesian space was obtained, and the point value of the position on a single joint controller was formed according to the modified coordinate.The joints of the robot are controlled by the speed closed-loop and position closed-loop systems to control the robot to move according to the specific attitude and position.The speed loop is located in the inner loop, while the position loop is located in the outer loop.

Cartesian coordinate system has the following characteristics: two number lines intersect at the origin and have equal units of measure, which can form a plane radial coordinate system.When these two numbers are perpendicular, we call them cartesian coordinates, and when they are not perpendicular, we call them Cartesian bevel coordinates.Cartesian coordinate system and cartesian coordinate system have similarities and differences, the similarity is that cartesian coordinate system and cartesian coordinate system are the description of the position of a point in space, under certain conditions, cartesian coordinate system can be transformed into cartesian coordinate system, cartesian coordinate system can also be transformed into cartesian coordinate system.And the difference is that cartesian coordinates not only have right angles but they can be non-right angles, and they can describe positions in space in a variety of ways including three dimensional coordinate matrices and position vectors.Fig.8.shows the Cartesian coordinate system.
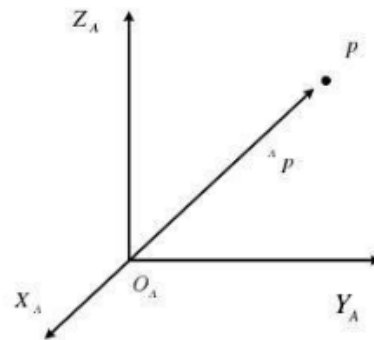

Fig.8.Cartesian coordinate system

3.4. *The PID algorithm*

In order to make the humanoid robot dance better, more accurate completion of the action, motor control usually uses PID algorithm, PID refers to the proportion, integral and differential control, after getting the system output will be output after proportion, integral and differential three operation modes, to overlay the input to make it up to the specified area and control motor position makes dance moves more accurate.Fig.9.shows the PID algorithm block diagram.
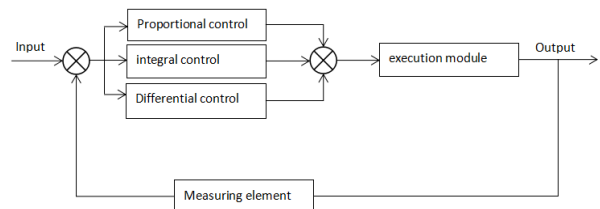

Fig.9.PID algorithm block diagram

3.5. *Motor*

Dance humanoid robot is can complete a variety of difficult moves, because each joint has equipped with motor, commonly used in present dancing robot motor mainly has three categories: dc motor, servo and stepper motors, they all have obvious advantages and disadvantages, including dc motor with low power consumption, torque, is often used in closed loop control system[5].Steering gear control precision,small torqueStepper motor control precision, large power consumption, small torque, is often used for open loop control system, which has obvious advantages and disadvantages of three kinds of motor, we adopt servo motor to dance for our robots "joint", realized the advantages of the servo motor position, speed and torque closed loop control, overcome the out-of-step problem of step motor, And strong overload resistance can withstand more than three times the rated torque of the load, and stable operation at low speed can not produce similar stepping operation phenomenon at low speed. Figure 3-10 shows the servo motor distribution of humanoid dancing robot.

Shoulder   Shoulder

Elbow   Elbow

Hand Waist Waist Hand

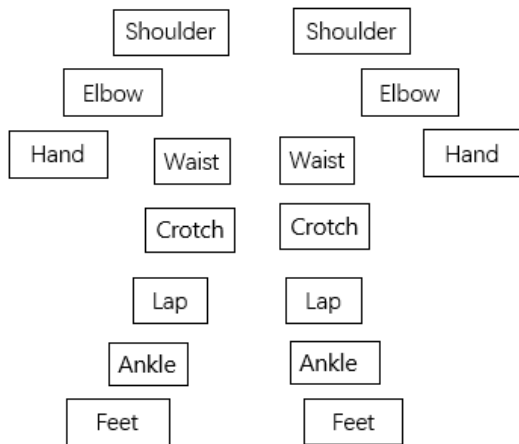Crotch Crotch

Lap Lap

Ankle Ankle

Feet Feet

Fig.10.Distribution of servo motors

4. Software design

For humanoid dancing robot, its control system includes two aspects, namely hardware system and software system. Hardware system is the basic system of the overall control, while software system is based on the hardware system.The software system consists of two parts: the upper computer software system and the lower computer software system.In the dynamic debugging of upper computer software, edit and debug the robot dance movements, and record the coordinate data information of each joint position to form a data information table about dance movements, and then send the position data information in the table to the lower computer system.According to the sent data information, the robot movement control to form a dance.Fig.11 shows the flowchart

Upper Control

Communication Control

Bluetooth Module

I/O

MCU
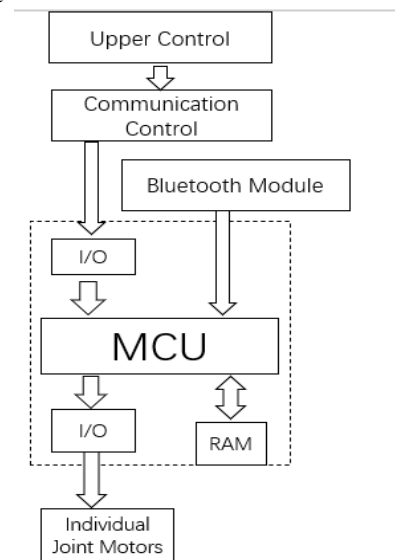
I/O   RAM

Individual Joint Motors

Fig.11.Control system block diagram

PC control dynamic debugging software dance robot movement there are two main ways: one is the online control, dynamic debugging by dragging the upper machine software on a joint corresponding sliding block can be directly observed the rotation to the Angle of the corresponding position, the real-time online watch dance robot joint position, easier to detailed debugging dance moves. The other is offline control, which is actually based on online control. That is to say, a dance posture should be adjusted by online control first, and the control data of each joint of the dance posture should be saved in the dance movement data sheet as a record of the movement table. Then a complete set of dance movements is an action table composed of multiple records. The data in the action table is downloaded to the lower computer, and the single chip microcomputer controls the dance robot according to the data in the action table to complete a complete set of dance movements. When using this control method, after the data in the action table is downloaded to the single chip microcomputer through the serial port, the serial port line can be unplugged to enable the dancing robot to complete

the dance performance independently under the control of the single chip microcomputer, so it is called offline operation.

5. Other parts of the humanoid dancing robot

5.1. *Costume design of dancing robot*

The costume design of the humanoid dancing robot is mainly for the following aspects:

- Deepen the theme so that the audience can remember the performance.
- Beautiful, enhance the beauty of dancing.
- Increase the adaptation and story with music.

The costumes of our humanoid dancing robot are independently designed, including lotus, auspicious clouds, wild cranes, tai Chi and many other elements, which are closer to the theme of the dance and deepen the meaning and connotation of the dance.Fig.12.shows the clothes.

Fig.12. Self-designed clothes

5.2. *Music and background design*

The AU software is used to gradually decompose each action frame of Baduan Brocade for music design, so that its actions can better fit each frame to achieve better dance performance and stage effect.

The background uses Chinese ink style tai Chi background video to make the dance more coordinated and story-telling. Resonates with the dress and dance itself, making it more vivid.Fig.13.shows the background design.

Fig.13. Background design

5.3. *Dance background and artistic analysis*

Baduanjin is a traditional Chinese health qigong. Regular practice of baduanjin can strengthen tendons and bones, dredge meridians and collaterals, improve gastrointestinal and cardiovascular functions, and improve human flexibility[3].As a product of high-tech development, robots can reflect a country's scientific and technological level to a certain extent. Eight jin as a basis, we believe that the eight period of jin is the treasure of the Chinese traditional culture, has a strong body, enhance the effect of cardiopulmonary function, especially in the outbreak of the new champions league now spread so quickly under the condition of constant, eight period of jin can not restricted by space, eight jin long do improve cardiopulmonary function well.

After the adaptation of the action to make it more ornamental and interesting, through the design, production, programming, debugging to make the baduan brocade vivid display, so as to achieve the combination of Chinese culture and modern science and technology [4].

6. Test result

After our test, the humanoid dance robot can complete independent dance, and can complete the baduanjin performance according to the dynamic debugging software of the upper computer, the dynamic debugging software of the lower computer and the PID algorithm. Fig.14. shows the static figure of the dance.

Fig.14. Static display of dance

7. Conclusion

Humanoid dancing robot system is relatively perfect, in the design aspect of machinery, control, music, choreography, etc., need to integrate and deepen each other, in the core design of the robot, the control system is the most critical, its design will have a certain impact on the robot itself. In the robot dance movement, the corresponding digital algorithm is used and the Cartesian coordinate system is established. Closed-loop feedback control can be used when positioning the robot walking path. In addition, synchronous compensation algorithm and PID algorithm can be used for walking and other movement problems.

The software and hardware structure of humanoid dancing robot is established, the coordination control system of robot music and dance movement is established, and the related strategies of music feature recognition are explained to realize the related control system of dance robot.

After the robot shape and system are assembled, some basic movements can be carried out according to the input system. However, dance robots are not human beings, so the center of gravity needs to be considered. Some movements that robots cannot complete cannot be forced to be completed.Due to the lack of innovation in related technologies, robots still have the following problems:The system computing capability is insufficient.The procedure of the whole robot adopts the method of single chip computer operation.Although the single chip microcomputer has a qualitative leap over the

past, the internal computing system of humanoid dancing robot is relatively large, and the existing single chip microcomputer is difficult to perfect the real-time information of the robot. Based on the above problems, we believe that the main research directions in the future are as follows. Use the controller applicable to the RTOS. The full name of RTOS controller is real-time Operating System, which is used to deal with real-time situations. It has high practicability, timeliness and flexibility while processing data. With the rapid development of technology and technological capabilities, microcontrollers have made continuous progress. It is believed that dance robots with RTOS will have higher flexibility and adaptability. We can install infrared photoelectric sensors in the chassis of the robot to detect the occurrence of the actual situation. The sensors can be divided into two groups, and the signals of each group of sensors are connected with the MCU by input. When the robot performs, no matter which area enters into the effective range of infrared ray, high level can be transmitted in time. And, or and NOT gate will be used to convert high level to low level and finally external interruption will be made to avoid rollover phenomenon.

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