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Control and Design of Dancing Robot based on STM32

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Abstract

The emergence and development of robot technology not only fundamentally changed the traditional industrial production, but also had a profound impact on society. With the rapid development of social technology, the application field of robots is expanding. In this paper, the control core of the proposed dancing robot is STM32F103C8T6 single chip microcomputer, the upper arm is controlled by the steering gear, the feet are two flexible wheels, and the DC deceleration motor is used as the driving motor of the wheels, so that the wheels of the robot can realize free movement and complete the dancing action of the robot. The power needed for robot movement comes from 18650 lithium battery. In the process of robot movement, the LD3320 voice recognition module is used to control the robot's movement direction and state, the MPU6050 is used to control the robot's balance, and the JQ6500 music playback module is added to the robot to control the music playback through voice recognition. After the power of dancing robot is turned on, the dancing robot starts to adjust itself to make its posture in a balanced and upright state, and then waits for the user to issue a command. The dancing robot has simple human body function and can complete simple dance actions such as moving forward and backward, walking left and right, turning left and right, and has voice function, and can also play music. The operation password is simple in the process of application, which makes it convenient for the user to use. In addition, the dancing robot is small in size and can move freely with good practical effect, regardless of the user's age.

Keywords: DC reduction motor, single chip, balance control, practicability, flexibility.

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1. Introduction

With the development of science and technology, robot has become one of the greatest inventions in the 20th century. The technology of robot has gradually matured, making the whole robot industry undergo earth-shaking changes. Robotic technology has influenced every industry, from automatic production line to fishery resource exploration, and even outer space work. In addition, in our daily life and work, there is the shadow of intelligent robots. Intelligent robots are taking the place of everyone's work in many aspects and playing an increasingly critical role. Robotic engineering is a complex course in scientific research, including artificial intelligence, computer, mechanics, electronic technology, computer, and other disciplines. Some advanced technologies in informatics and electronics are increasingly applied in the field of robotics.

1.1 Analysis of current situation of dancing robot

From the perspective of robot products released worldwide in recent years, robot technology has developed towards intelligent system, modularization, and specialization. The key to its development trend is modular construction and reconfigurable open control system that is PC-based and digital. Servo motor driver is technically intelligent and decentralized. Dancing robots have been developed at different levels successively in Japan, South Korea, the United States, China, and other countries. Especially in Japan, there has been groundbreaking development. At the level of high-tech robotics, China is still in its infancy. In recent years, it has been applied successively in scientific research, national defense, industrial production, agriculture and animal husbandry and other industries, especially in industrial production. As far as China is concerned, robots rarely develop into the entertainment industry. When robots appear on the stage of game entertainment, they will eventually make the entertainment methods more modern and diversified, and increase the variety of entertainment content. It can not only bring people enjoyment, but also record the dance movements in numbers, facilitating the rapid transmission of culture and art, and thus completing the inheritance of traditional Chinese culture under the characteristics of the data era. At this stage, there is a big gap between the ownership of AI in China and the market demand, and the market prospect of intelligent robots is great [1].

1.2 Research objectives and practical significance

In order to better meet the needs of children and parents for dancing robots and enable them to develop brain growth while playing, through interviews and market research, the needs of children of different ages, parents' opinions on dancing robots, and the advantages and disadvantages of current products on the market have been analyzed, and some principles for the design of dancing robots have been derived, and it is recommended that dance robots should have certain interactive capabilities, and the function of entertaining and playing with children. Under normal environmental conditions, it can exercise flexibly, and finally train children's brain tonic development by playing music. The robot designed in this work can strengthen children's brain training in terms of functions, and the added entertainment functions effectively alleviate children's boredom and monotony. Through password-controlled robots, children's interactive ability and language training can be enhanced, stimulating children's desire to explore, and the application effect in real life is good.

2. General design scheme of dancing robot

The main structural components of the dancing robot, including the foot, head shell, hand shell, leg shell, etc., are made by 3D printing technology to reduce the production cost. The control core of the robot is STM32F103C8T6 single chip microcomputer, the upper arm is controlled by the steering gear, and the physical part is simulated by the steering gear. The feet are two wheels with high flexibility. The gyroscope MPU6050 is used to control the balance and steering of the robot. Two DC deceleration motors are used as the drivers of the wheel movement to complete the robot's dance action. The power module required for the robot's movement is from the 18650 lithium battery. During the robot's movement, the LD3320 voice recognition module is used to control the robot's movement direction, and the password is used to change the robot's movement. At the same time, the music playback module is added to the robot, and the voice recognition controls the music playback [2].

2.1 Overall system design of dancing robot

According to the design objectives and technical indicators of the dancing robot, the modular design idea is mainly adopted. First, the SCM STM32F103C8T6 is used as the main control module. When the dancing robot is powered on, it first detects the balance through its own gyroscope MPU6050. When the dancing robot is not balanced, it first adjusts itself to

achieve the balance state. Then the user gives the password, which is input by the microphone, converted into an electrical signal and transmitted to the speech recognition module for speech recognition, and finally transmitted to the main control module of the single chip computer to judge the password through the main control module. If the password conveys the dance password, the signal is transmitted to the steering gear 1 and steering gear 2, and the robot arm responds and starts to dance. If the input password is the movement password, the main control module controls motor 1 and motor 2 to steer the two wheels to move, such as forward, backward, turn and other actions. If the password transmitted is the password for playing music, the main control module will transmit the signal to the music playing module, which will play music [3]. The design system structure of the dancing robot is shown in Figure 1.

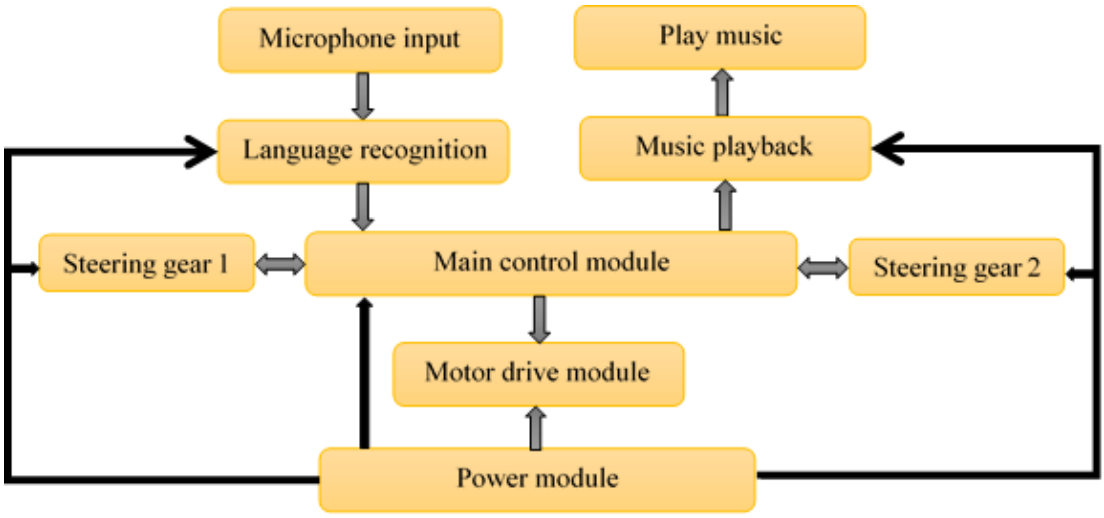


Figure 1. Design system structure of dancing robot

2.2 Main control module of the system

STM32F103C8T6 single chip computer is the main control module of the dancing robot. The voice recognition module, music playback module, drive module and balance control module are connected in the circuit. When the dance robot starts to work and there is a password coming in, it processes the password coming in from the voice recognition module, and then STM32F103C8T6 single chip computer transfers the processed data to the corresponding control module. The module executing the command converts it into the corresponding command to complete the upper arm turn. The control of walking and music

playback enables it to perform the corresponding actions to meet the user's requirements [4]. The minimum system circuit diagram of STM32F103C8T6 is shown in Figure 2.

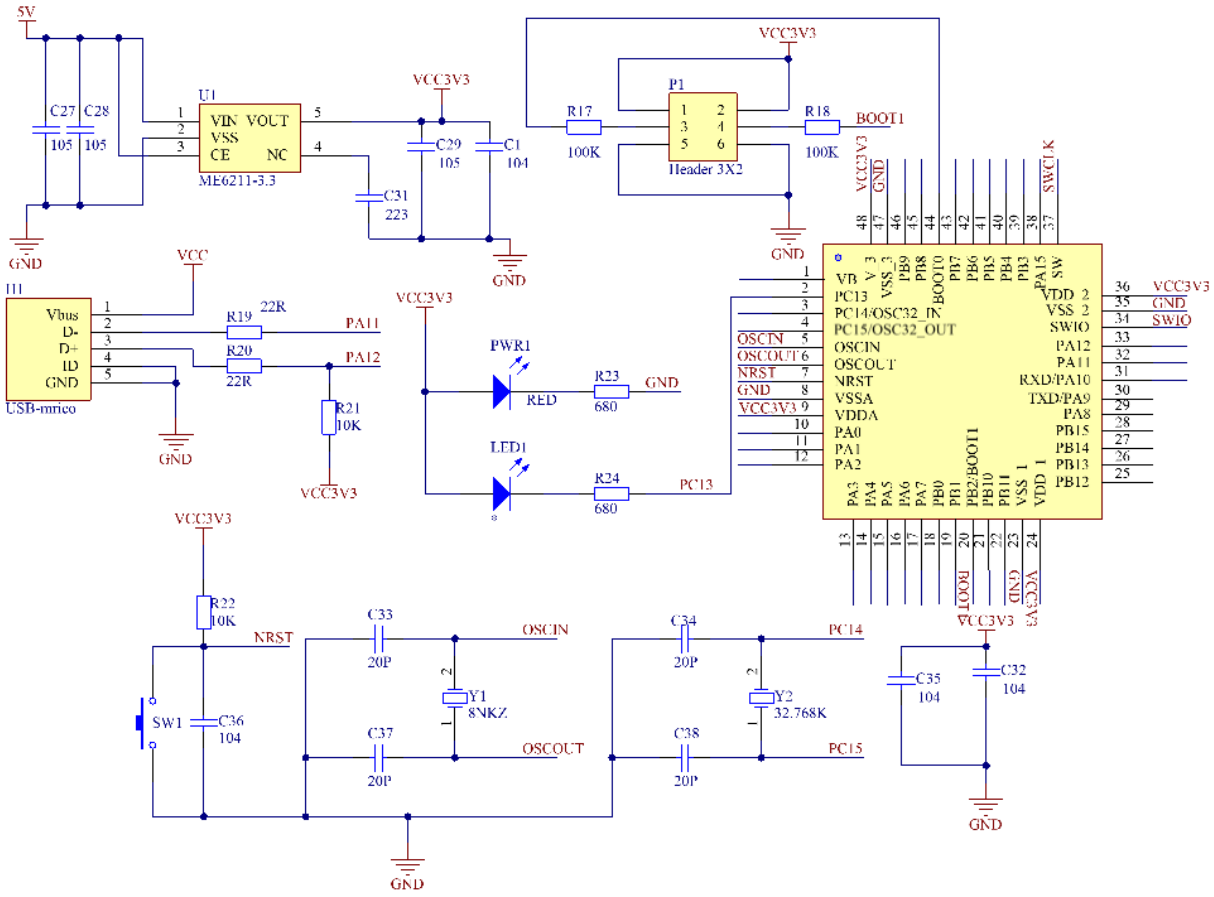


Figure 2. Circuit diagram of the dancing robot

In the design scheme of the dancing robot, the L298N drive module is used. This module uses the L298N typical dual-H bridge DC motor drive chip of ST enterprise, which can drive DC motor and two-phase stepping motor. This drive module is very small, light, strong anti-interference, and has strong driving capacity: 2A peak current and 46V peak voltage. The addition of freewheeling diode can avoid the damage of the chip caused by the azimuthal induction electromotive force of the motor electromagnetic coil when the power is turned off. Although the chip has the function of fully automatic shutdown when it is overheated, the installation of heat removal chip can reduce the temperature and make the driving characteristics more stable. The drive module is equipped with two current feedback inspection sockets, internal logic power selection terminals, four pull-up resistance selection

terminals, two DC motor sockets and four two-phase stepping motor sockets, control motor orientation display lamps, and four standard fixed mounting holes [5].

In the power circuit of this design scheme, the key driver is two DC motors. ENA and ENB are effective at high power level. The control mode machine and DC motor status are shown in Table 1.

Table 1. Motor drive enabled meter

ENA	IN1	IN2	DC motor status
0	X	X	Stop
1	0	0	Retardation
1	0	1	Forward
1	1	0	Reversal
1	1	1	Retardation

In the whole process of driver module application, if PWM speed change must be carried out for DC motor, IN1 and IN2 must be set to specify the rotation direction of the motor, and then PWM single pulse can be output at the end to complete the speed change. In particular, when the data signal is 0, the motor is at random termination. When the enabled data signal is 1 and IN1 and IN2 are 00 or 11, the motor is in the braking system to prevent the motor from rotating. The L298N drive circuit diagram is shown in Figure 3.

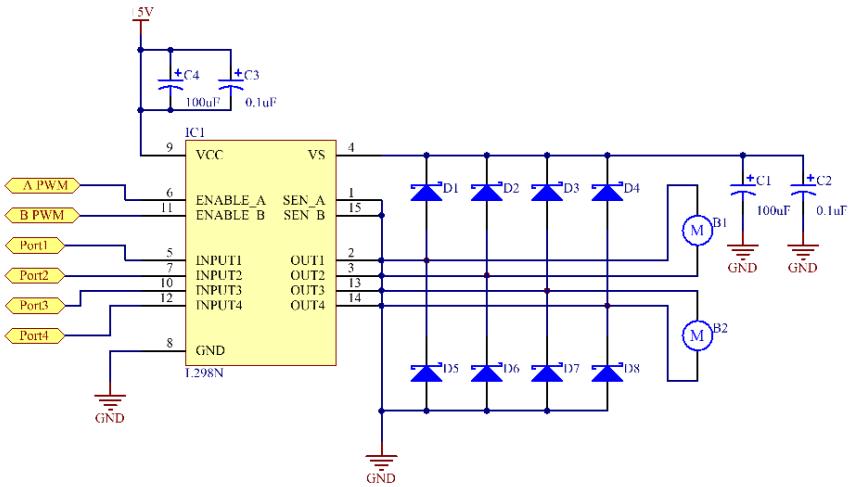


Figure 3. L298N drive circuit diagram

2.4 Speech recognition module of dancing robot

In the design scheme of dancing robot, LD3320 speech recognition module has been chosen. LD3320 is an integrated speech recognition technology based on non-special human speech recognition technology. The LD3320 speech recognition technology control module integrates the precision machined A/D and D/A sockets, so that the speech recognition technology can be implemented without external auxiliary flash and RAM, and the intelligent voice and human-computer combat exchange effect can be achieved. LD3320 has two application modes, namely trigger recognition mode and circulation system recognition mode. Users can set two different application modes according to the program. In the circuit design of the dancing robot, the cycle recognition mode is adopted. This mode perfectly matches the requirements of circuit design and can fully meet the requirements of the designer. The circuit diagram of LD3320 speech recognition module is shown in Figure 4.

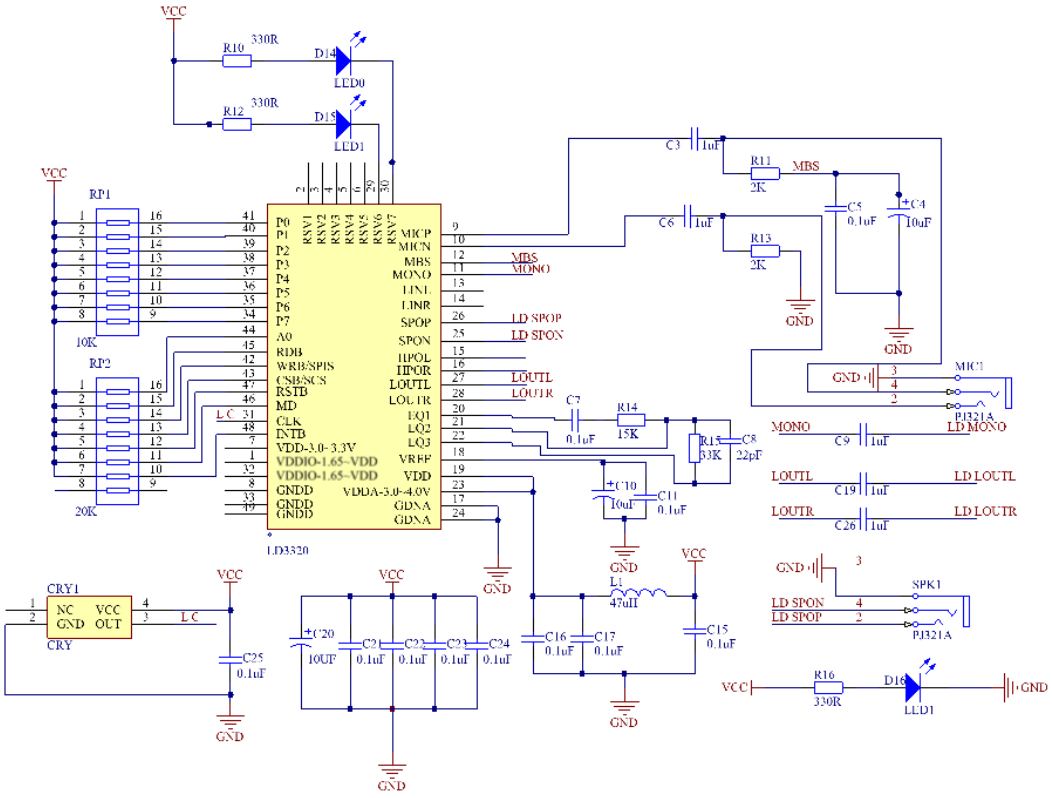


Figure 4. Circuit Diagram of LD3320 speech recognition module

2.5 Music playback module of dancing robot

JQ6500 music playback module is an MP3 module that provides serial communication and integrates hard decoding of MP3 and WMV. The JQ6500 integrated chip adopts the SOC plan, which integrates a 16-bit MCU and a professional ADSP for audio decoding. The hard decoding method is used to ensure the reliability and timbre of the system software. According to the simple serial communication command, a specific song can be played, and how to play the music can be given. It is easy to use, stable and reliable without complicated bottom practical operation. The interface of JQ6500 chip connecting peripheral devices is 3.3V TTL level, and the peripheral circuit is used for power supply. The voltage module installed in the circuit can fully meet the power supply requirements of the module. In the design of hardware circuit, it is necessary to deal with the level conversion problem. In addition, in the environment of strong interference, electromagnetic compatibility is well protected, GPIO adopts optocoupler isolation, and TVS is added [6]. The circuit diagram of JQ6500 music playback module is shown in Figure 5.

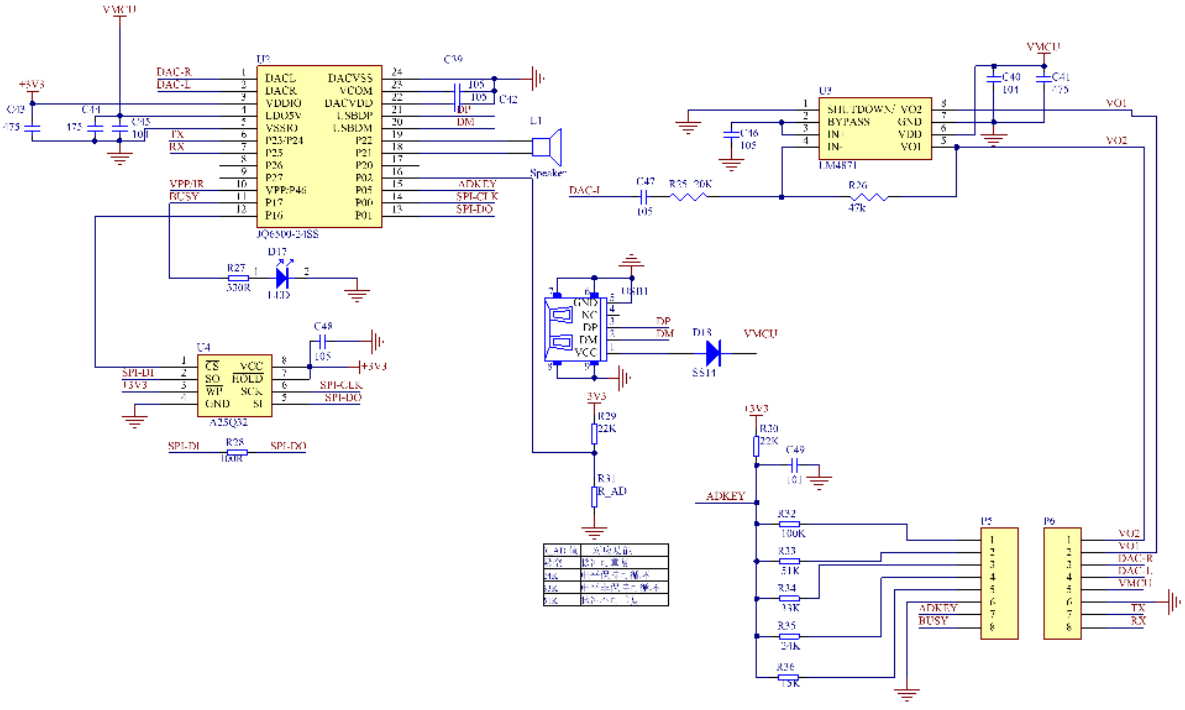


Figure 5. Circuit Diagram of JQ6500 music playing module

2.6 Balance control module of dancing robot

In the design scheme of the dancing robot, the MPU6050 six-axis sensor module is used to control the balance of the intelligent robot. The MPU6050 module is an integrated

six-axis motion solution. Compared with the multi-component planning scheme, it eliminates the problem of composing the hand gyroscope and accelerator, and reduces the installation room space. The MPU6050 module integrates a 3-axis gyroscope and a 3-axis instantaneous speed sensor internally, and has a second IIC socket, which can be used to connect external magnetic sensors. It uses the built-in data CPU and hardware accelerator module to output detailed 9-axis combined calculation data information to the application end according to the IIC socket. The circuit diagram of MPU6050 six-axis sensor module is shown in Figure 6.

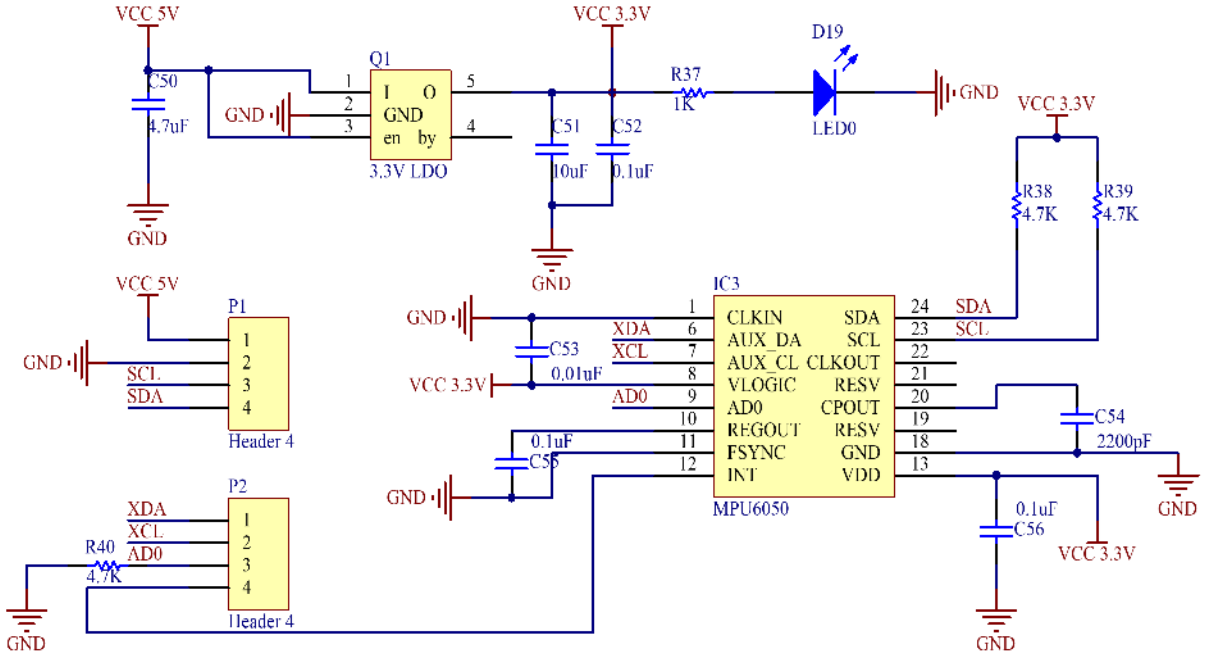


Figure 6. Circuit Diagram of MPU6050 six-axis sensor module

3. System software design and implementation

In the design of dancing robot software, the main designed passwords include dancing, forward, backward, playing music, turning left and right, etc. After the user utters the password, the LD3320 speech recognition module in the circuit recognizes it. After receiving the password, the speech recognition module first converts it into characters and sends it into the chip. Then the LD3320 speech recognition module sends the identified data to the STM32F103C8T6 single chip computer. Finally, the STM32F103C8T6 single chip computer acts as the main control module and executes it according to the data, that is, the

dancing robot makes corresponding actions. After the system is powered on and started, all modules in the circuit begin to work, and the DC motor is in the standby state. In the process of software program design, the system is first initialized, so that the dancing robot is in the state of receiving commands, and then the balance of the car is detected. In the process of detection, the main MPU6050 six-axis sensor module is used. If the dancing robot is not in the upright balance state, the dancing robot is first balanced and adjusted to be in the upright state. After the dancing robot reaches the use state, it can start to accept the external password, execute the password command, and make the same action as the password [7]. The flow chart of the overall software is shown in Figure 7.

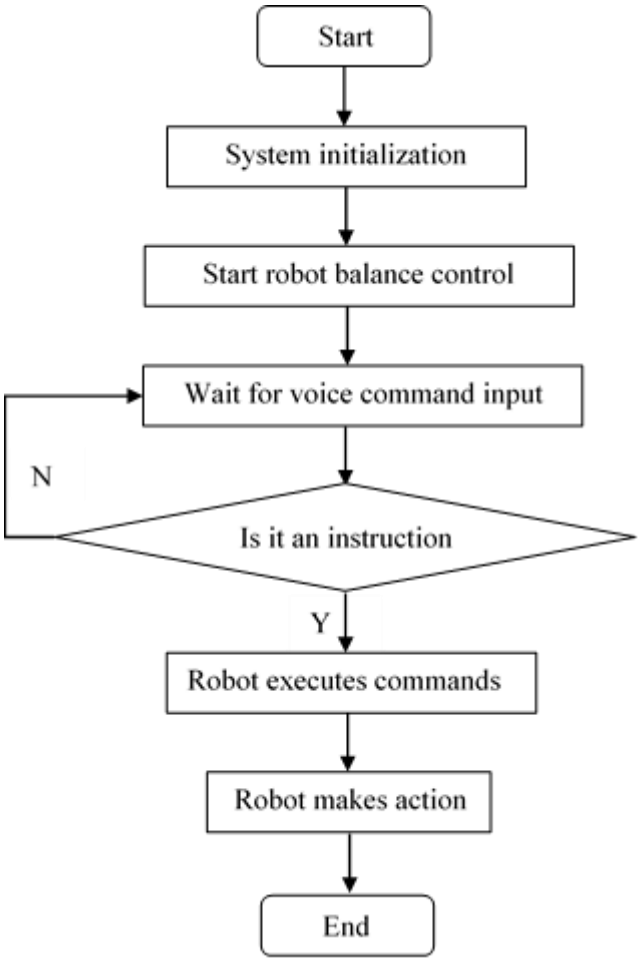


Figure 7. Flow chart of the overall software

According to the overall diagram of the software, the main program of the system is mainly responsible for the timing process of the entire system, including initialization of system settings, stack pointer settings, interrupt vector settings, and the main program loop

structure of the system. Then, the initialization of the system mainly includes the initialization of dance actions and registration of initialization.

In the design of dancing robot, the LD3320 voice recognition module has the functions of recognizing password, voice control and human-computer dialogue. It is small in size, low in power consumption, accurate in recognizing password, more convenient, accurate and rapid in data transmission, and has a wider range of applications, which meets the needs of personal and social information, without wiring, health and safety. The LD3320 speech recognition module amplifies the input audio signal through an amplifier, and then passes it into a filter for low-pass filtering to thoroughly eliminate noise. After the sound is processed, a space that can be safely judged and quantized between several nodes is formed, and then the numbers in this space are transmitted to the communication interface. Finally, the module uses a hardware chip to perform semantic analysis of the audio and complete instruction recognition. The flow diagram of the speech recognition module is shown in Figure 8.

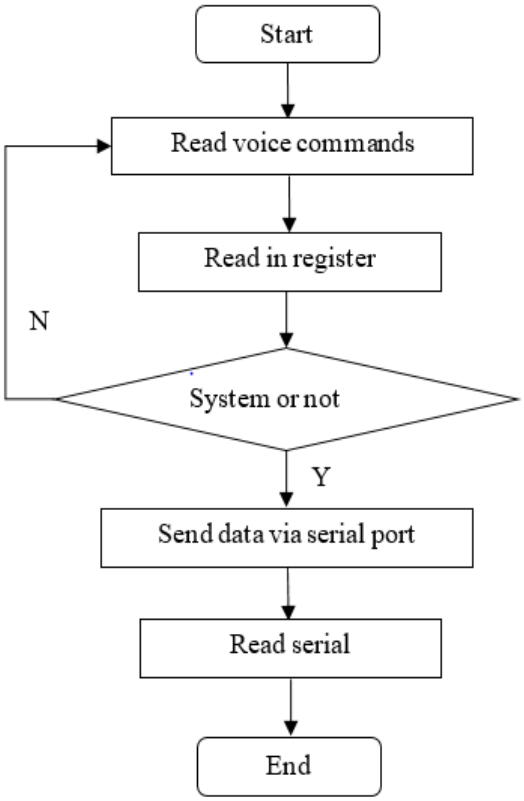
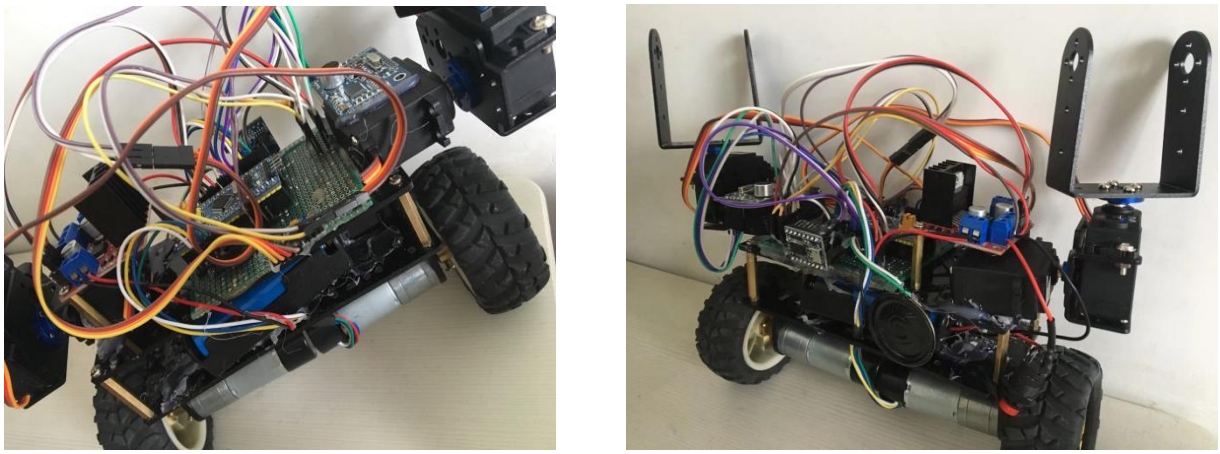


Figure 8. Flow chart of speech recognition module

In the speech recognition flowchart, the system's speech recognition system mainly includes speech extraction, storage, recognition, transmission, and related interrupt service subroutines. It is an important part of the design of the dancing robot system. The LD3320 speech recognition module mainly performs speech recognition in this system, transferring the identified password to the main control system, which processes the transmitted data. After processing, the main control system transfers the specific data to the corresponding module which performs specific operations, and finally the dancing robot makes the corresponding actions.

4. System commissioning and testing

In this system, the hardware circuit board is welded with the universal board. Compared with the PCB board, the universal board is cheaper, has more flexible layout, and the has a lower threshold for use. The hardware are not welded directly, but the whole components are welded on the universal board [8]. The physical model of the dancing robot is shown in Figure 9.



Figures 9a and 9b. Model of the dancing robot in different views

In the design of the dancing robot, the upper arm of the physical part of the dancing robot uses the steering gear for simulation. When the dancing robot starts, the password to dance is entered, and the dancing robot starts to perform the dancing action. In the process of design, due to the difficulty of design, the upper arm of the dancing robot is first simulated.

When the program written by the steering gear is set to forward rotation, the D14 and D16 lights in the circuit are turned on, and the black steering gear in the simulation circuit diagram rotates forward. When the set program is reverse, the D6 and D13 lights in the circuit are turned on, and the black icon in the simulation circuit diagram rotates in the reverse direction. Each steering gear is matched with a motor, and the direction of motion of the steering gear is set by the program. When the dancing robot executes the command of dancing, the motor under each steering gear is in forward direction, driving the steering gear to move continuously, and the simulation effect is good. The dancing function of the dancing robot has been basically realized [9]. The steering gear simulation circuit diagram is shown in Figure 10.

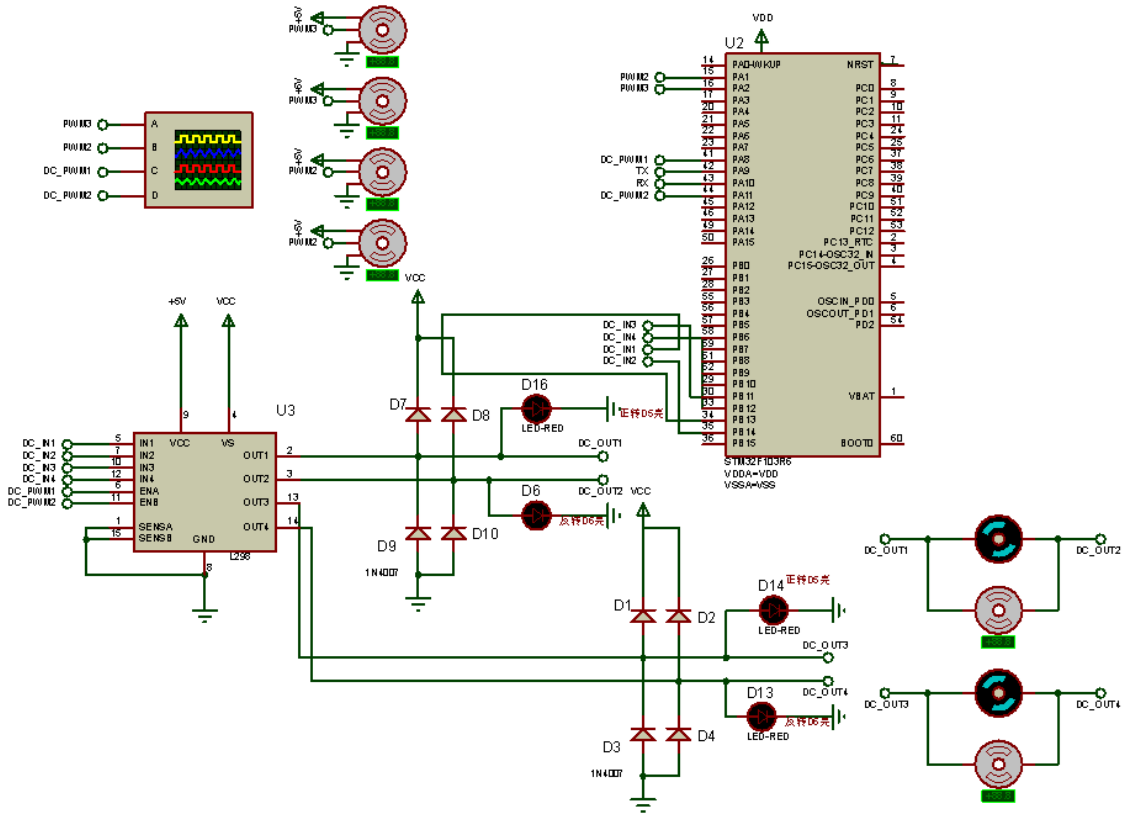
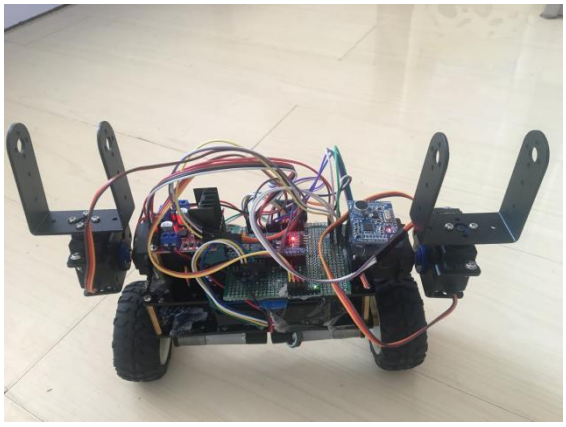
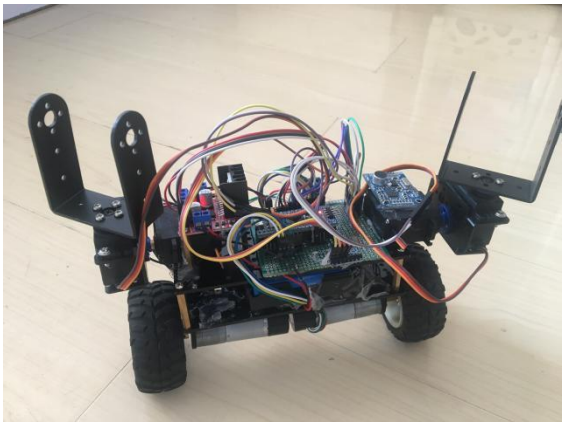
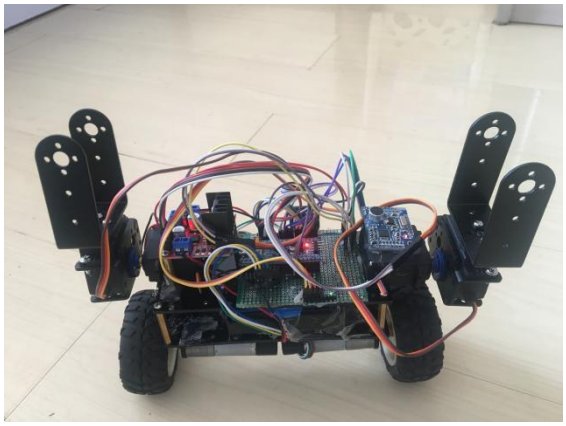
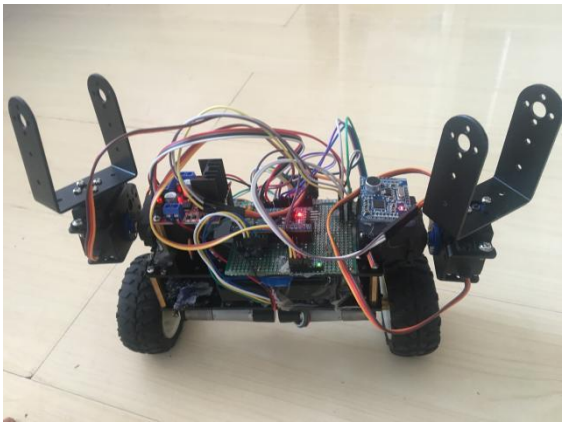


Figure 10. Circuit Diagram of Steering Gear Simulation

5. Results and Discussion

After integrating the circuits of each module together, the overall design circuit diagram is obtained. At this time, the system module layouts the required components on the

circuit board according to the design of the circuit diagram. The physical motion diagram of the dancing robot is shown in Figure 11.

Figures 11a to 11d. Physical motions of the dancing robot

In the physical design of a dancing robot, the upper arm of the dancing robot is simulated using a steering gear, so that if there is a problem with the dancing robot, parameters can be adjusted as soon as possible. As can be seen from Figure 11, when the power supply of the dancing robot is turned on, the lights on the circuit board used in the physical model are all lit, and the dancing robot starts up normally, and the system starts initializing. From Figure 11a, it can be found that the robot's steering gear is in a horizontal state, waiting for the user's command. After the user enters the dance password, the dancing robot starts to dance. From Figures 11a to 11d, it can be found that the images of rotating 45 °, 90 °, 135 ° and 180 ° are intercepted, and the steering gear of the dancing robot is continuously rotating, which proves that the functional test of the dancing robot is good. In

addition, other functions of the dancing robot were tested, such as playing music, moving forward, and moving backward. During the testing process, some small problems occurred, but after continuous optimization and improvement, the problems were resolved through testing, and the design goal has been basically achieved. The designed model is compact and flexible, and has good applicability. Compared to the existing dancing robots, that integrated art, music, and robotics in Singapore's early childhood centers [10], it is found that this proposed dancing robot can attract children's attention to a greater extent, has better performance, and is easy for children to handle due to the smaller size model.

6. Conclusion

This proposed work accomplishes the designing of a dancing robot. First, the design principles of general purpose, low cost and low power consumption are determined. According to the design requirements, the technical indicators and software design tasks of dancing robot are given, and the hardware and software designing is carried out around these technical indicators and tasks. The hardware circuit includes: STM32F103C8T6 single chip microcomputer minimum system circuit, LD3320 voice recognition circuit, JQ6500 music playing circuit, L298N drive circuit, and MPU6050 balance control circuit. The software part includes the design of single-chip circuit, voice recognition circuit, music playing circuit, driving circuit and balance control circuit. The overall scheme of the dancing robot designed is feasible and can achieve the expected results. The design has the characteristics of simple operation, economic benefits, reliable work and powerful functions.

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Author's biography

Yan-jun Li is currently studying for a postgraduate degree at Liaoning University of Technology in Jinzhou, China. Her research topic is controlling and designing of dancing robot based on STM32.

Ya-jun Wang was born in Huludao, China in 1978. She received her doctorate in control theory and control engineering from Northeastern University in 2015. She is a professor at Liaoning University of Technology in Jinzhou, China. She has written more than 30 articles. Her research interests include multivariate statistical modeling, process monitoring and fault diagnosis and their applications in industrial processes.