Design and Implementation of a Drum Robot Based on ROS

Liping Su 1, Dong Chen 2*, Jie Luo 1

1 Guangxi Technological College of Machinery and Electricity, Nanning, 530007
2 Guangxi Teachers Education University, Nanning, 530023, Nanning, P.R. China

* Email Address: hgccd@163.com

Abstract. This paper introduces the design and implementation of a robot that can be used to play the Dragon drum. In order to satisfy the requirements of automatic playing, music selection through gesture recognition, improvisation through gesture control and so on, ROS (Robot Operating System) is employed to achieve the integration of heterogeneous hardware. After testing, the robot runs stably, plays automatically and accurately, and responds quickly to the improvisation play.

1.Introduction
With the progress of the times, the further development of computer technology and automatic control technology, as well as the gradual maturity of networking technology and robot technology, the research and application of robot are being further developed. Thus, the design and application of robot is not only limited to the industrial environment, but gradually walks into the daily life of mankind. Therefore, music robot, sweeping robot, cooking robot, interactive teaching robot and robots of other different functions emerged.

Music robot falls within the scope of special robot which is specialized in performance. There are usually two types of design priority for music robot: one uses playback device and it focuses on the interaction with people while the other directly plays real musical instrument and attaches importance to authentic sound. According to the different types of instruments, robot of this kind can be divided into string music robot, wind music robot, keyboard-typed robot and percussion music robot. The percussion music robot often consists of a plurality of mechanical arms, and it is usually equipped with agile moves, strong sense of rhythm, good vision and auditory effects. Therefore, it is the research direction that is mostly favored. This paper focuses on the design of a drum robot, who uses six 2-degree freedom mechanical arms to simulate man’s behaviors of playing for the purpose of achieving music performance.

2.Overall Design

2.1 Working Principle
In the design of the drum robot, the user signals instructions to the drum robot through gesture and the signal can be transmitted to the human-computer interaction module through the sensor of gesture recognition. Then the gesture recognition can be conducted in the human-computer interaction module and the recognized instruction can be transferred to the Raspberry Pi in the main control module through WiFi. After that, the Raspberry Pi can choose the music that will be played or the operations that is to be implemented and sent them to the singlechip in the main control module. After receiving the signal, the singlechip will control the drum robot’s robotic manipulator to move and eventually play
corresponding music.
The appearance of the structure of the drum robot is shown in Figure 1:

![Figure 1 The appearance of the structure of drum robot](image)

Figure 1 The appearance of the structure of drum robot

2.2 Overall Design of the System
The whole structure of the robot can be divided into three sub-system modules--power module, main control module and human-computer interaction module, and the idea of modular design is reflected in the design process. The power module is responsible for supplying power to the other modules in the robot system; the main control module is mainly in charge of completing the data communication with the other modules and processing the data received on instruction control so as to control the robotic manipulator to perform; the man-machine interaction module is used for the recognition of the gesture instruction. The overall design diagram of the control system is shown in Figure 2.

![Figure 2 The overall design diagram of the system](image)

3. Hardware Design of the System
The hardware design of control system owned by the drum robot is designed alone according to the individual sub-modules in the overall design, which enhances the scalability of the control system and facilitates the maintenance of the system.

3.1 The Main Control Module
Based on the functional requirements of the drum robot, the design of the main control module is mainly conducted on the basis of the following points.

① Human auditory organs are very sensitive to time difference for the rhythm of music.

Because of the above characteristics of human hearing, the time control of music playing is relatively stringent, which requires that control system which directly control the mechanical movement must be strictly real-time. The employment of single-chip bare-metal programming is deemed as the easiest way to ensure real-time control system. As for the mechanical control part of the hardware system, the STMicroelectronics STM32F103R6 single-chip is chosen as the core.

The single-chip of STM32 series is based on the core of ARM Cortex-M3 and it is designed for systems of the embedded type for which the characteristics of high performance, low cost, and low power consumption are required. Its characteristics are shown as follows:

1) a 32-bit processor.
2) the operating frequency that is up to 72MHz.
3) 32Kflash memorizer and 10K data memorizer.
4) 51 multifunctional bidirectional I / O ports
5) 7-channel DMA, controller

② The function of remote control is in demand because the robot is required to have the ability to interact through network.

Single-chip of STM32 series satisfies the real-time requirements, but its ability of network
interconnection is weak. Moreover, it is difficult to build up user-friendly GUI interface. Therefore, the structure of combining host computer with lower computer is adopted by robot--the lower computer can complete the work that is relatively simple but high in real-time requirements, while the host computer is mainly responsible for the advanced functions such as networking, data processing, and data storage etc.

Raspberry Pi 3B is a microcomputer that is the size of credit card, and its system is based on Linux. With the configuration of ARM Cortex-A53 1.2GHz 64-bit quad-core ARMv8 CPU, 1GB memory, wireless card, and Bluetooth, it is small in size and it is the host computer commonly used by the robot system.

In this paper, Raspberry Pi is used as the host computer that is responsible for the song access, network interconnection and other functions while controlling the work of the lower computer.

3.2 Human-Computer Interaction Module

The human-computer interaction module mainly undertakes the responsibility of the user’s sending gesture instructions to the robot. The gesture instructions that needs to be recognized by robot are mainly divided into two categories: one of them is static gestures, which are mainly responsible for the selection, play control, switches of music and so on; the other is dynamic gestures, which are mainly used to achieve the function of remote improvisation.

Based on the above requirements, the simple gesture sensor based on infrared is unable to meet relevant requirements because of the types of the gesture recognition and the requirement for the speed of gesture recognition demanded by improvisation. The selection of gesture sensor based on vision is an inevitable choice. In this paper, LeapMotion is chosen as the gesture recognition sensor for drum robot.

LeapMotion is able to track the 10 fingers which moves at the speed of 200 frames, and the accuracy is up to 1/100 mm. Through it, the coordinate of each joint of every hand and the facing of the palm normal can be obtained, which can fully meet the demand of the robot. However, the requirement for its computing capability is high and it only supports the processor of X86 architecture. In the existing common embedded platform, the Edison platform of Intel has X86 architecture and powerful ability in computing and networking, which can fully satisfy the demand.

3.3 Power Module

The power module can guarantee the normal operation of the entire control system. For the purpose of simplifying the power supply system and improve the reliability of the control system, all the power modules use the standard 5V power supply uniformly. At the same time, the 12V power supply is employed by taking into account the power needed for the arm movement of drum robot.

3.4 Mechanical Part

In order to pursue a better dragon drum playing effect of the drum machine, three drums are employed as musical instrument. Each dragon drum is equipped with two robotic arms with hammers and the whole robot has a total of six robotic arms. Because different sound effects can be achieved by tapping the drum in different locations in the drum playing, two degrees of freedom are set for each robot arm. As each degree of freedom is driven by a large torque steering gear, tapping on the different locations of the drum can be flexibly achieved. The six robotic arms are supported by tripod, and the end of the arms are connected to the circular base at the top of the bracket and the end of every two robotic arms are mounted at the intervals of 60°, and every two arms are usually treated as a group in music playing.

4. Design of System Software

According to the hardware design of the robot, it will be found that the types of hardware of robot are large in number and a variety of heterogeneous hardware need to be integrated. ROS (Robot Operating System) is a set of operating system architecture owned by computer designed for the development of robot software. It is an open-sourcing meta-level operating system (post-operating system) that provides
services similar to the operating system, including description of hardware, management of underlying device driver, execution of shared functions, inter-program messaging, and management of program release package. Moreover, it also provides some tools and libraries for the acquisition, establishment, compilation and implementation of the program for multi-machine integration. ROS is quite suitable for integrating different hardware. As both the Raspberry Pi and Edison Platform are equipped with Linux systems, ROS can be installed on both of them. A variety of functions owned by ROS system can be achieved through the node, and the communication between nodes can be achieved through Topic and Message. Moreover, network communications can be achieved by simple settings, and the communication details will be packed by ROS. The node of ROS is shown in Figure 3 as follows:

![Figure 3: ROS node graph](image)

The node of sender is provided directly by ROS, and it uses the official SDK based on the leap motion sensor. Although it is simplified and can only provide the data of a palm, it is enough for the machine. By the way of subscribing to relevant topics, the coordinates of finger joints and palm normal sent by sender can be obtained to facilitate the recognition of gestures. At present the gestures can be recognized are pause (hold out the thumb while retracting the other four fingers), music election (holding out the index finger refers to the first song and the rest can be done in the same manner), following fingers performance (unbend both the index finger and middle finger straight and draw them close to each other) and so on.

5. Conclusions
This paper describes the working principle and the overall design, as well as hardware design, mechanical design and software design of the drum robot system. With the characteristics of shorter development cycle, strong capabilities in integrating the differentiated hardware and so on, the design is completed on the basis of the ROS framework. The robot uses the real dragon drums for the performance of drum music and the sound effect is quite real. By using gesture recognition as the instruction control of users, the functions of remote control, automatic performance and improvisation can be realized. After testing, the performance effect of the drum robot is quite true and the operation of gesture recognition is sensitive, which satisfy the design requirements well.

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References
[1] Xiaodong Fu. Music Robot Development History and Technological Achievements [J]. Performing Arts: 2015, 5: 12-17
[2] Xinbin, Han, Chensheng Wang. A Design and Implementation of Combat Music Robot [J].. Software: 2013,34 (1): 1-3.
[3] Yadong Zhang, Xueliang Ge. Multi-function Intelligent Robot Design Based on Single-chip Microcomputer [J]. Communication Technology: 2012,45 (1): 96-98.
[4] Jianying Guo, Tiansheng Lv. Foreign Music Robot Research [J]. Mechatronics, 2002,3: 14-17.
[5] Weihua Huang. Based on the Raspberry Pi Gourd Playing Robot Design and Development D].
Wuhan: Wuhan University of Science and Technology, 2016.