

Design and Implementation of a Micro Controller for Robot Sensing and Driving

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Abstract

According to the control requirements of robot, the micro controller was designed, including the interface for the wireless transmission module NRF24L01, the sampling circuit for collecting the pressure sensing value, the DC motor drive function module, and the auxiliary circuit for ensuring the normal operation of the controller. After passing the hardware testing, the design of the PTZ control system is completed. The virtual reality environment is constructed using unity and VS software, Oculus is used as the head-mounted display, and then the pose sensor of Oculus is used to analyze and extract the pose sensing data for the control of the PTZ. The industrial camera is used to send back video, based on HSV algorithm for target recognition, and displaying video images in the virtual environment. And the above data was sent to the gimbal control system to finalize the virtual reality environment. Finally, the debugging and verification of the hardware architecture based on sensing and driving and the virtual reality environment were completed. And the scenario tests were conducted for the gimbal following and force feedback virtual interaction ball respectively, which verified the use of virtual reality technology to assist in controlling the robot and obtain the sense of immersive control experience.

Keywords

Circuit Design; Virtual Reality; Sensing and Actuation; Data Interaction.

1. Introduction

The embedded hardware architecture plays an increasingly important role in various fields[1], but with the rapid development of robot intelligence, more and more data exchange between its sensors, actuators and computing devices, then the reliability and power consumption of the controller put forward higher requirements[2], at the same time in most of the robot control, such as the traditional joystick + 2D display control, its single participation in the control mode of operation, in the operation process is almost "senseless" experience, the lack of immersion and experience, easy to cause boring distraction, operational efficiency is not high, leading to a series of problems[3, 4]. With the rapid development of virtual reality technology in recent years, there is another option for controlling robots, namely using VR devices to assist in controlling robots[5]. Operators can achieve subjective environment perception in VR head-mounted displays, from a single manual control mode to an immersive control that matches people's daily behavior, and control robots to work in depth. The use of virtual reality technology as an auxiliary control can significantly enhance the sense of presence of robot operation, which is beneficial to receive more information and effectively improve the flexible and accurate control of the robot, thus improving operational efficiency. Combining robotics

and virtual reality technology with perceptual control system will become one of the research hotspots in the field of artificial intelligence.

2. Design of Microcontroller System

The embedded micro controller determines a good hardware design according to the VR device and control requirements[6]. The VR device is Oculus quest2 and the control requirements are: (1) Control the head movement with the head, for the control of the head, design the wireless transmission module to receive the information of the VR device head pose.(2) Force feedback interaction experiments, the process of applying pressure to the pressure sensor micro-controller to collect pressure data, and wirelessly transmit the value to the virtual scene control virtual interaction ball real-time changes, while the instructions generated by touching the virtual interaction ball sent to the micro-controller to drive the corresponding angle of the DC motor. Design the hardware module of micro controller based on sensing and driving, use electronic drawing software Altium Designer to design the schematic diagram and PCB, after the board making is completed, then use programmable voltage regulator and high precision digital multimeter DMM6500 for testing, covering the basic auxiliary circuit, motor driving module, wireless communication module and sampling circuit module, and then design the head control system.

Eventually, after completing the hardware testing of the basic circuit, sensing and driving parts using the relevant test equipment, the system was basically able to achieve the required functions, and the system ran stably and worked normally, which proved the feasibility of the functional modules and laid the foundation for the subsequent adoption of virtual reality technology to assist in controlling the gimbal following and virtual interactive ball.

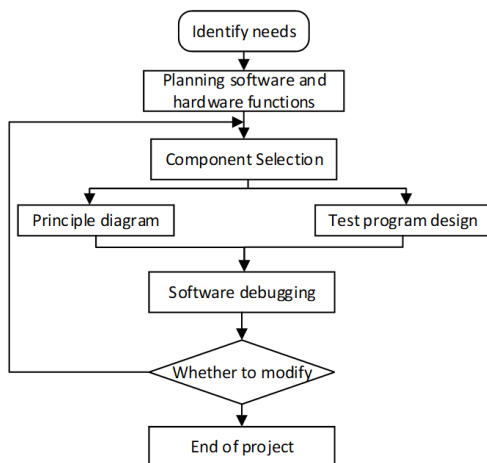


Figure 1. Hardware Design Flow

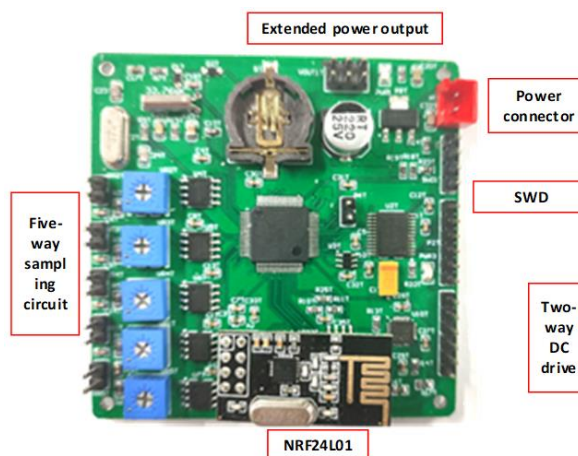


Figure 2. Micro Controller

3. Design of VR Virtual Reality System

The virtual environment is built in four major modules, namely UI interface, posture Sensing, target recognition and wireless transmission. First build the required base model using 3Ds Max and finally integrate it into the unity virtual scene. Then write functional components in Visual Studio using C#, add functional components to the base environment using unity to achieve the corresponding functional requirements, and finally run the unity game engine with Oculus quest2 for wireless streaming, and then execute the corresponding motion.

1) The UI interface consists of three parts: the virtual head interaction scene, the information prompt and the image display canvas, which is the scene that the operator can see when the system is running.

2) The posture sensing aspect is to analyze and extract data from Oculus' sensors, and to obtain the posture motion sensing data of Oculus quest2 through head movement, and then send it to the micro controller to smoothly control the movement of the head.

3) In terms of wireless communication, the communication between the Oculus quest2 and the PC is achieved through the official self-contained wireless streaming, and the PC and the micro controller are realized through a pair of NRF24L01 modules. First of all, Oculus needs to control the computer, it needs OculusPC client and Oculus head-mounted display for wireless streaming, after the realization of Oculus can control the computer, and then control the PC side of the unity virtual environment, which realizes the Oculus and PC data interaction, followed by the PC side and micro controller using NRF24L01 wireless communication.

4) Target recognition is based on the HSV algorithm, which recognizes different objects based on different colors.

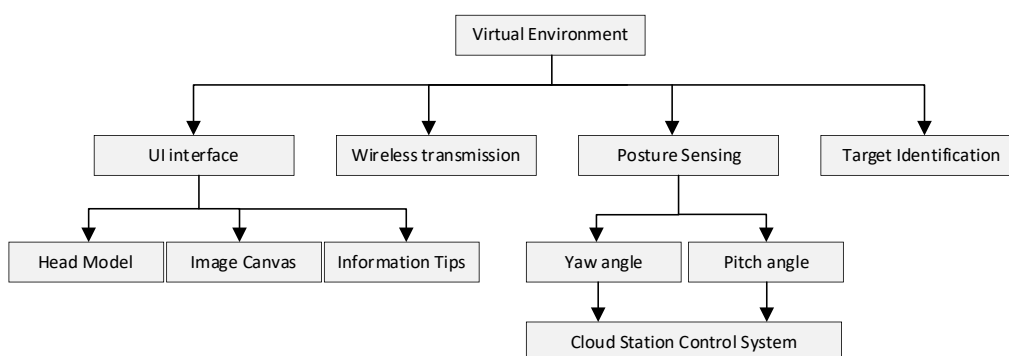


Figure 3. Cloud Station Control Flow

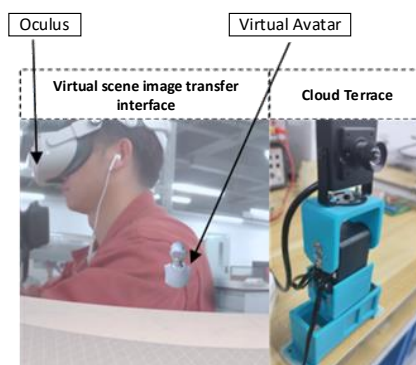


Figure 4. Cloud Station Control Interaction Interface

4. Application Scenario Testing

At the end, two application scenarios were tested, using the virtual reality system on the basis of the micro controller, the software and hardware control of the gimbal follow-me and the virtual interactive ball were carried out respectively to experience the immersive control, the virtual interactive ball was able to change with the pressure and the gimbal was able to move synchronously with the head.

The head pose in the Oculus SDK includes a 3D position vector and orientation quaternion, with rotation held as a unit quaternion, and finally the API for the head pose is called and extracted and analyzed into yaw and pitch angle data in the form of a conversion transfer to the head. Oculus quest2 The angle values collected from Oculus quest2 are processed by Visual Studio on PC, the pitch data and yaw data will be transmitted wirelessly to the micro controller for

controlling the pitch motion and yaw rotation of the gimbal respectively, the data on the left is the yaw angle and the right is the pitch angle.

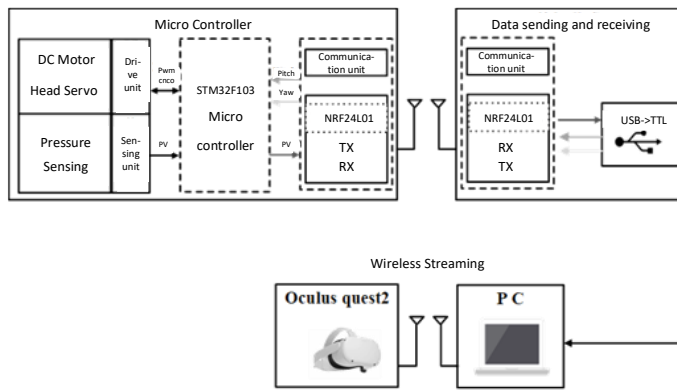


Figure 5. Data Flow Chart

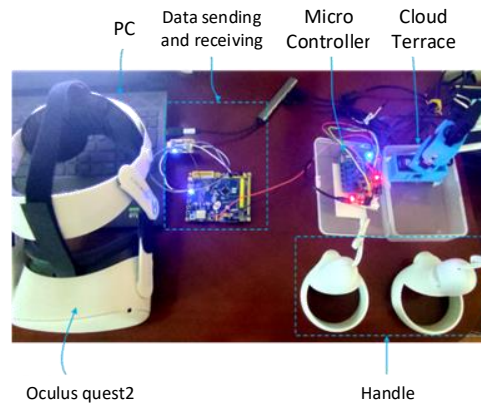


Figure 6. Overall physical picture

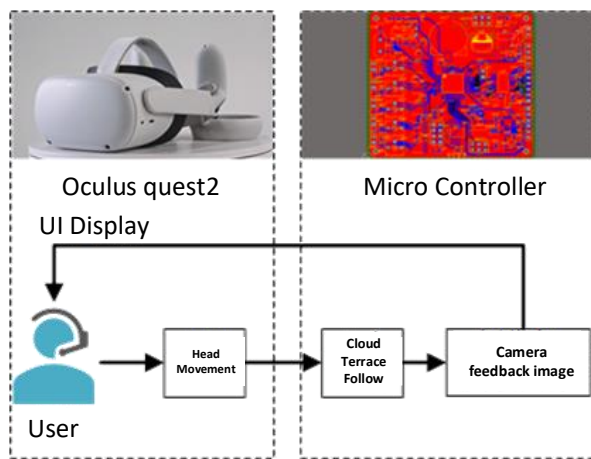


Figure 7. Cloud station with interactive demo

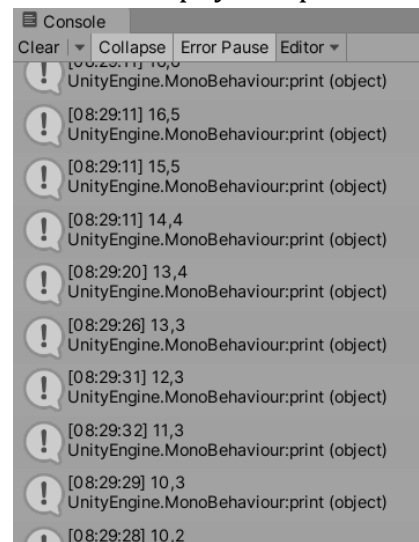


Figure 8. Data sending

Many virtual scene manipulation jobs for grasping or manipulation can usually use simulation-controlled virtual hands [7], whose position and motion are roughly based on hand tracking devices for tracking, while Oculus is using the four cameras of the headset to track hand motion, thus allowing the use of virtual hands to interact with virtual objects in a reasonable way, such as pinch grasping and ray picking, as shown in Figure 9, which generally divides the grasping process into four processes: virtual hand mapping, pre-grasping pose, stable grasping pose and grasping motion.

This experiment is based on a pressure sensor for force feedback control. The control scheme consists of a force sensitive resistor (FSR), a sampling circuit and a micro controller which has been embedded in the micro controller. The micro controller processes the film sensing pressure signal and then transmits the pressure value to the virtual scene through the wireless communication module to make the virtual interactive ball change in real time, as shown in Figure 10.

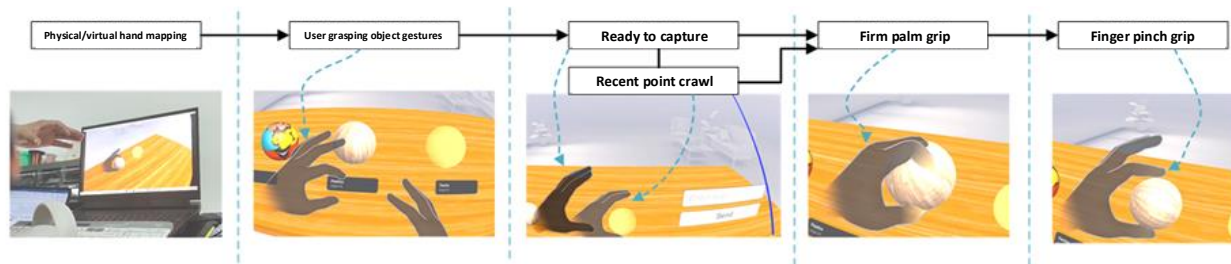


Figure 9. Crawl Demo

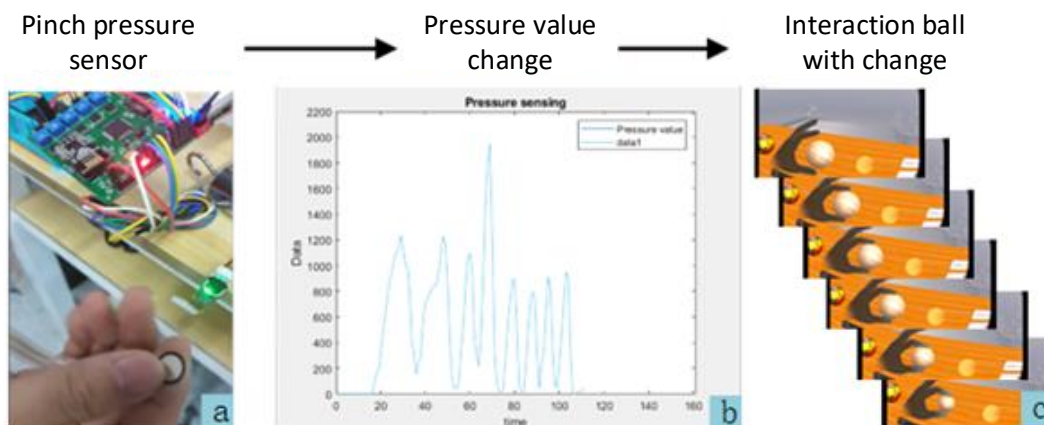


Figure 10. Force feedback scenarios

5. Conclusion

This paper designs a miniature controller for robot sensing and driving, using virtual reality technology as an auxiliary control. The operator is able to control the robot smoothly with a better immersive feeling by immersively operating the robot motion through customary head movements and watching the images returned from the robot camera in real time in the virtual environment.

Acknowledgments

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