Proceedings of the 2005 IEEE
International Conference on Mechatronics
July 10-12, 2005, Taipei, Taiwan

Remote Controlled Game Platform by USB Joysticks

Ching-Chang Wong, Wei-Wen Wang, Ya-Ling Lee, and Cheng-Hui Wu

Department of Electrical Engineering, Tamkang University
Tamsui, Taipei Hsien, Taiwan, Republic of China

***Abstract* - In this paper, a designed and implemented method of a robot soccer game platform is proposed. This platform includes three main parts: (a) four joysticks and each with an USB connector, (b) a transmission electric board with four USB connection ports, and (c) four omni-directional mobile robots with three-wheel mechanism. Players can control the omni-directional robot to play a soccer game by using USB joysticks through the wireless communication.**

Index Terms* - *Robot soccer game, USB joystick, Wireless communication, Omni-directional mobile robot, Intellectual Property.

I. Introduction

The diagram of the remote controlled game platform by USB joysticks is shown in Figure 1. This platform includes three main parts: (a) four joysticks and each with an USB connector, (b) a transmission electric board with four USB connection ports, and (c) four omni-directional mobile robots with a three-wheel mechanism. The transmission host electric board has four USB connection ports that can provide four robots to play a soccer game in the field whose length and width are 80 cm x 120 cm. Each half field has a goal, and the ball used in game is a standard orange golf ball. The joystick with an USB connector used by the player can be bought in the market. The photograph of the remote controlled game platform is shown in Figure 2.

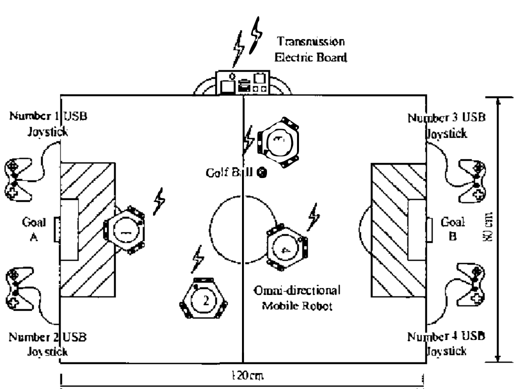


Fig.1. Diagram of the remote controlled game platform by USB joysticks.

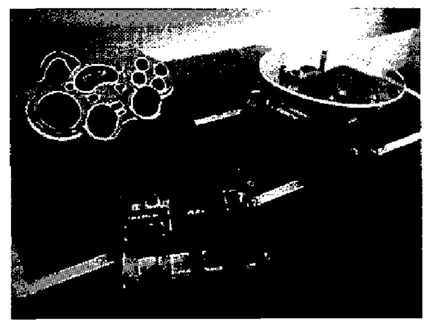


Fig.2. Photograph of the remote controlled game platform by an USB joystick.

The function block diagram of the remote controlled game platform is shown in Figure 3. The characteristics of this system can be divided into two parts: (a) software IP (Intellectual Property) and (b) hardware function. The software IP has: (a) USB control IP, (b) omni-directional mobile control algorithm, (c) wireless communication technology, (d) robot ID recognition, and (e) PWM speed modulation. The hardware function has: (a) omni-directional mobile robot, (b) motor feedback precisely control, (c) three-layer electric board, (d) LCM display module, and (e) high efficiency gear box. The system flowchart of the overall system is shown in Figure 4. In the whole system, some control software IPs are proposed and implemented in a FPGA chip to collocate with outside hardware, like: USB joystick, wireless communication modem, omni-directional mobile mechanism, ID recognition apparatus, motor control circuit and so on to realize each function of this platform.

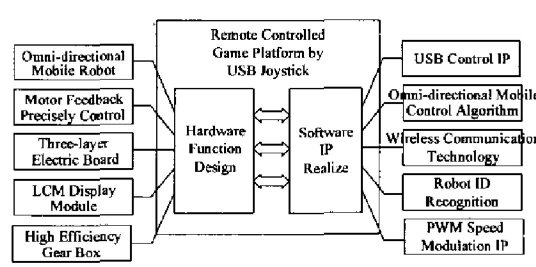


Fig.3. Function block diagram of the remote controlled game platform.

The rest of this paper is organized as follows: In Section 2, the proposed control IP of this system is described. In Section 3, the proposed circuit and mechanism of the system are described. In Section 4, the simulation and experiment discussions of the system are described. Finally, in Section 5, some conclusions are made.

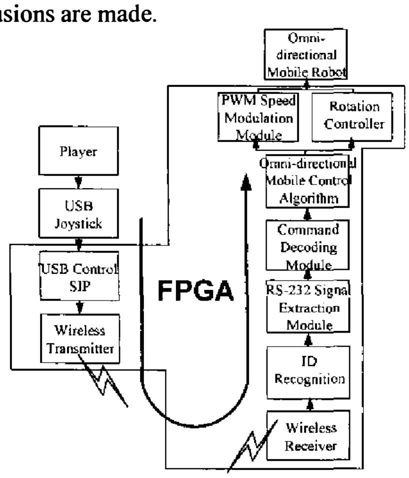
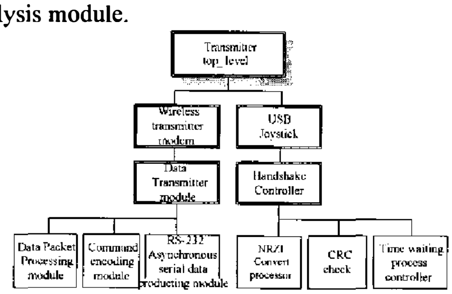


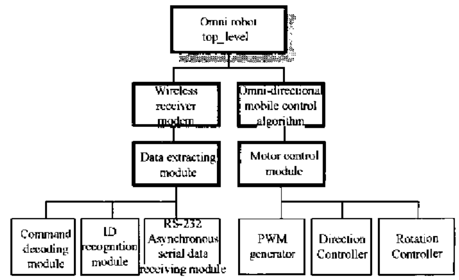
Fig.4. System flowchart of the overall system.

II. Design of The Control IP for The System

In this section, the control IP which is written in VHDL for this system is proposed. The architecture diagram of the proposed control IP is shown in Fig. 5, where there are two parts: (a) host transmitter IP and (b) robot receiver IP. The function of the host transmitter IP is designed for handshaking between the FPGA chip and the USB joystick. And further, the host transmitter IP will transmit information to robots that are in the field through the wireless communication modem. The function of the robot receiver IP is designed to extract correctly commands from data packets and decode the received command, which are received from the wireless modem. Through the omni-directional mobile control algorithm, the FPGA control chip creates some appropriate signals to control three motors separately and analyzes the feedback signals from motors. In the proposed control IP, there are six modules: (a) USB control IP, (b) omni-directional mobile control algorithm, (c)wireless communication module, (d) robot ID recognition module, (e) PWM speed modulation module, and (f) motor feedback signal analysis module.



(a) Architecture diagram of the host transmitter IP.



(b) Architecture diagram of the robot receiver IP.

Fig.5. Architecture diagram of the control IP.

III. Circuit Board and Mechanism Design of The System

The control circuit board and the mechanism design of the implemented omni-directional mobile robot are respectively described as follows:

3.1. Control Circuit Board

The photograph of the host transmitter circuit board of the system is shown in Fig. 6. The photograph of the control circuit board of the omni-directional mobile robot is shown in Fig. 7. There are five main parts: (a) USB connection circuit, (b) FPGA main control chip, (c) wireless communication circuit, (d) regulated power supply circuit, and (e) motor driving circuit. These functions are illustrated as follows:

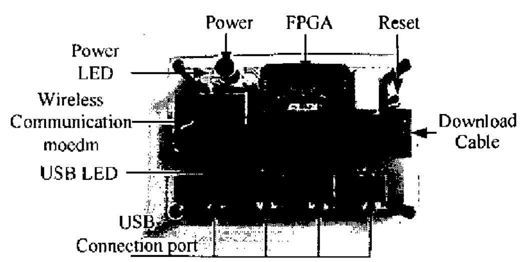


Fig.6. Photograph of the host transmitter circuit board of the system.

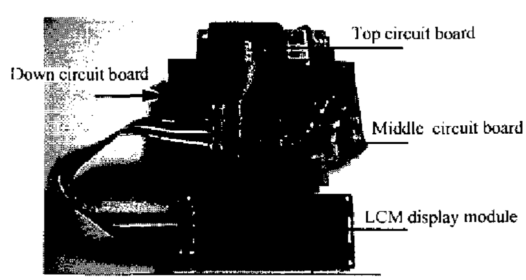


Fig.7. Photograph of the control circuit board of the omni-directional mobile robot.

(a) USB Connection Circuit

According to different transmission speed (full-speed, high-speed, and low-speed), the hardware of USB connection differs from each other. In the case of low-speed transmission, the apparatus will add a pull-up resistor in C- signal line so that the processor can judge what kind of transmission speed is used of the apparatus. Furthermore, the processor can also detect if the USB connector is plugged in or removed.

(b) FPGA Main Control Chip

The main control chip of this system is Altera EPF10K10 FPGA chip of FLEX10K set and Altera developing software MAX+PLUSII is used to develop the control IP. Because the integrated circuit of FLEX10K set is the SRAM type, thus a programmable memory must be added externally. In this system, Altera's EPC2 flash memory is used to be a program download chip.

(c) Wireless Communication Circuit

The adopted wireless communication module is BiM3 wireless communication modem. Its communication distance is 30 meters indoors, or 120 meters outdoors. Because this modem used in system is a low power cost BiM3 module, hence we design its correlate circuit base on the data sheet.

(d) Regulated Power Supply Circuit

The adopted battery in this system is rechargeable nickel-metal hydride battery. Its normal voltage and current are 1.2V and 800mAh respectively. There are two parts of voltage supply in the implemented robot. One part is 5V logic circuit and wireless modem voltage, and the other part is 5V motor driving circuit voltage. For separate the current of logic circuit and motor driving circuit. Hence six 1.2V, 800mAh rechargeable nickel-metal hydride battery are used to be the 7.2V power supply of the robot, and two regulated power supply IC 7805 are used to convert 7.2V into 5V regulated power separately.

(e) Motor Driving Circuit

All actions of the omni-directional mobile robot are accomplished by controlling the rotations of three motors separately. The used motors are DC motors (6V, 8,200rpm) with feedback signal. When the FPGA chip is used to control the motors, an electrical switch, which is controlled by signals from FPGA, must be used to drive the motor. In this system, TOSHIBA's TA7291 IC is adopted to be the driver. In order to make the motor's speed be faster, the motor and the PWM signal output are separated by a photocoupler (PC827). Therefore, we can control the speed of motor from 5V to 0V.

3.2. Mechanism Design of the Omni-directional Mobile Robot

The omni-directional mobile robot is formed by three omni wheels. The photograph of the base of the omni-directional mobile robot is shown in Fig. 8. As shown in Fig. 9, the omni wheel not only can move in the x direction but also can move in the y direction. Hence the implemented robot with such base and wheels can move in any direction even turn revolving as it moves. The comparison diagram of moving paths for traditional cars and the omni-directional mobile robot is shown in Fig. 10. In the mechanism design, SolidWorks is used to design the external mechanism and parts of the robot. We use acrylic as material to fabricate the robot. The photograph and external view of the omni-directional mobile robot is shown in Fig. 11. The explosive view of the omni-directional mobile robot is shown in Fig. 12.

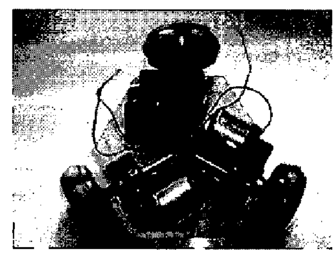


Fig.8. Photograph of the base of the omni-directional mobile robot.

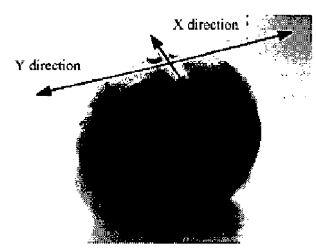


Fig.9. Photograph of the omni wheel.

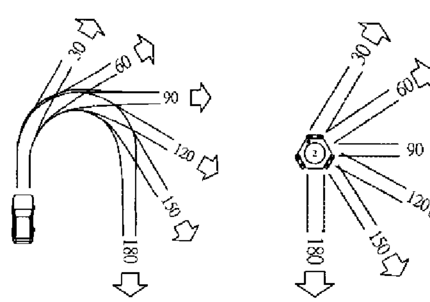


Fig.10. Comparison diagram of moving paths for traditional cars and the omni-directional mobile robot.

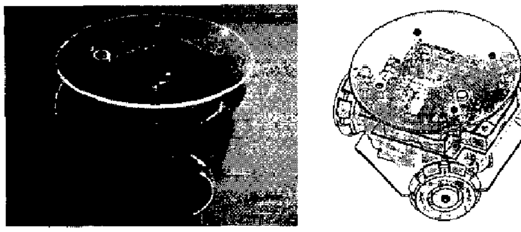


Fig.11. Photograph and external view of the omni-directional mobile robot.

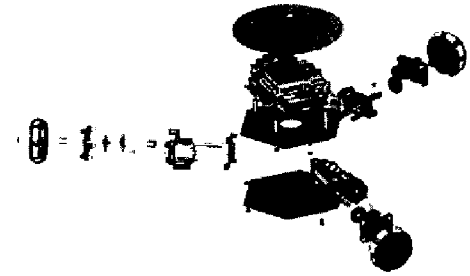


Fig.12. Explosive view of the omni-directional mobile robot.

IV. Simulation and Experiment of The Proposed Control IP

The synthesis and layout of the control IP are completed by the Altera FPGA developing software: MAX+PLUSII. In this section, the MAX+PLUSII's simulation diagram is used to illustrate the functions of the control IP. The simulation diagram of the omni-directional mobile control algorithm is shown in Fig. 24. We can see that the control signals for three wheels are completed separately in one clock time when the rotation and speed signals are given. Thus, the proposed algorithm is a high speed operation of the control algorithm for the omni-directional mobile robot. The simulation diagram of the data extracting function of the control IP is shown in Fig. 26. In Fig. 26, we can see that the number of robot is set to be 3 (numb_sel=3). When "rxd" gets the data of the stop byte "FFH", then the asynchronous serial data receiving module can extract the third data (command = 91D5) from data packets correctly. Finally, a LCM display module is designed to display two messages: (a) ID number of the robot and (b) the speed and rotation of three wheels (W1, W2, W3). The photograph of the LCM display module is shown in Fig. 25.

V. Conclusions

A control IP with an USB joystick control IP and the other IPs is proposed to design and control an omni-directional mobile robot. It is written in VHDL and implemented in a FPGA chip. A high speed control algorithm with one clock operation time is proposed for the omni-directional mobile robot. The implemented remote controlled game platform by USB joysticks is a mechanism and electric integrating system. From practical verify and test, we can see that the implemented platform indeed meets these basic terms of complete functions and high efficiency in the design and realization of this system.

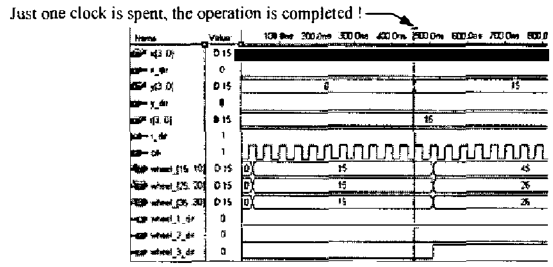


Fig.13. Simulation diagram of the omni-directional mobile control algorithm.

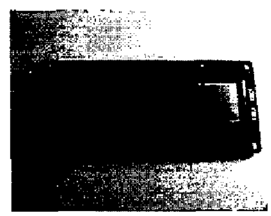


Fig.14. Photograph of the LCM display module.

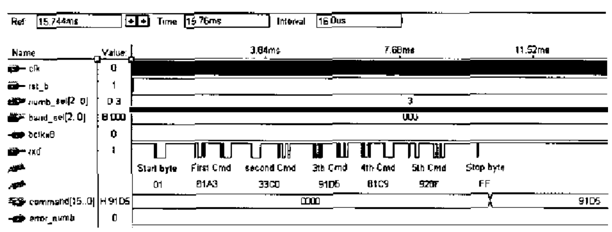


Fig.15. Simulation diagram of the data extracting function.

Acknowledgement

This research was awarded the first runner-up of the 4th Macronix Golden Silicon Awards.

References

[1] Z. Navabi, *VHDL Analysis and Modeling of Digital Systems*. McGraw-Hill Inc, 1991.

[2] C.H. Roth, *Digital Systems Design using VHDL*. PWS Publishing Company, Park Plaza, Boston, 1997.

[3] Z.C. Chen, *SOPC System Design*. Taiwan, 2003.

[4] Z.A. Lin, *USB 2.0 Program Design*. Kings Information Co., Ltd, Taiwan, 2002.

[5] L.Y. Technology, *SolidWorks 2004*. Taiwan: Acore Digital Technology Inc, 2003.

[6] URL : http://www.altera.com/

[7] URL : http://www.radiometrix.co.uk/

[8] URL : http://www.mxeduc.org.tw/