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Arm Equipped Exploring Robot

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Keywords：Labview, Robot, Myrio, KNR.

ABSTRACT

In this study, LabVIEW and KNR are used to develop an arm equipped exploring robot with different control modes for operating the arm. Each sensor and the robot arm are controlled through wireless transmission. The exploring robot is also equipped with a webcam, ultrasonic distance sensor, lithium battery, and wireless USB adapter for robot vision, distance sensing, power supply and wireless signal transmission, respectively. Robot arm control comprises two modes, namely, keyboard and motion control modes. The keyboard control mode collects keyboard input information through Wi-Fi wireless transmission to KNR for operating the robot arm control and mobile robot. A learning function in also included in the keyboard control mode. The user can customize a number of arm positions, so that the robot arm can repeat movements. Motion control collects information from a leap motion sensor through Wi-Fi wireless transmission to KNR, and the implementation of motion control can simulate the hand movement.

INTRODUCTION

Numerous mobile robot systems need operation capability, such as rescuing, soil sampling, and self-healing, so that they can perform various dangerous tasks for humans (Milkell, 1986). These robots are equipped with robot arms, such as the American robot TALON (Bodenhamer, 2010) with a robot arm in front and the Japanese robot HELIOS VIII with an arm that can capture an object. For legged robots, a hexapod robot can enhance mobility and provide a relatively simple control; thus, it is appealing for search, rescue (Billah, 2008; Karalarli, 2004), and planetary exploration (Massari, 2004). Therefore, a robot with six legs is a good compromise of simple control with four legs and stability with eight legs.

The design of an arm-equipped exploring robot is expected to undergo various missions that are unsuitable for man, such as in areas with bomb, gas, high voltage, and high temperature. Therefore, the manipulation of the robot is a very impotant issue to be concerned (Fujita, 2014; Chen, 2006). Small mobile robots are important in the mobile robot family. They can perform better in some special tasks, such as small-space exploration and camouflage detections, than large mobile robot systems. Small mobile robot systems have become a research hotspot due to their unique advantages, such as small size, low cost, and high mobility.

In this study, we developed a small-wheel mobile robot system and described its mechanical, sensor, and control system designs in detail. The presented robot system, compared with the previous robot system (Wu, 2015; Lin, 2010), is equipped with a webcam, ultrasonic distance sensor, lithium battery, and wireless USB adapter for robot vision, distance sensing, power supply, and wireless signal transmission, respectively. Robot arm control includes two modes, namely, keyboard and motion control modes. The keyboard control mode collects keyboard input information through Wi-Fi wireless transmission to KNR (Rehman, 2015) for operating the robot arm control and mobile robot. A learning function , is concerned as a major AI(Artificial Intelligence) deploymnent, is designed in the keyboard control mode for customizing a number of arm positions, so that the robot arm can repeat movements (Jaanus, 2014; Guo, 2016). The motion control mode is an advanrage for robot arm control (Ameur, 2016; Pititeeraphab, 2016). The robot arm can respond to the hand gesture immediately without keybord operation. Keyboard control and motion control have their control advantages respectively. But none of researches integrate these two control methods together (Lee, 2008; Moldovan, 2014; Caligiore, 2010; Kimura, 2015).

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MATERIALS AND METHODS

The controller and software used in this research are KNR and LabVIEW. KNR is a NI Single-Board RIO embedded hardware device that places dual-core ARM® Cortex™-A9 real-time processing and Xilinx Spartan-6 LX45 FPGA. It has 28000 programmable logic units, 16 analog inputs, 6 analog outputs, 40 digital I/O channels and sound I/O channel. KNR also includes a Wi-Fi, a three-axis accelerometer, and display LEDs that are built inside. LabVIEW is a data-flow graphical programming language (G-program), which plays an important task in the arm-equipped exploring robot for software control design use. LabVIEW is also highly related to industry applications (Yao, 2016; UrsuȚiu, 2104; Awaar, 2015).

RESULTS AND DISCUSSION

In this reseach, Wi-Fi is applied for wireless signal transmission control. In order to have remote control on the arm equipped exploring robot, NI KNR is set up as a base station for communication between computer and robot. Once the network interface card inserts into the adaptor port of KNR, network configuration can be defined as Fig. 1.

The robot system applies NI KNR also as the embedded control system and utilizes three-wheel carrier equipped with a robot arm to construct an exploring robot as Fig. 2. The software part uses the LabVIEW program and Fig. 3 shows the front control panel. The functions of control design include sign in, real–time image, wheel carrier and robot arm.

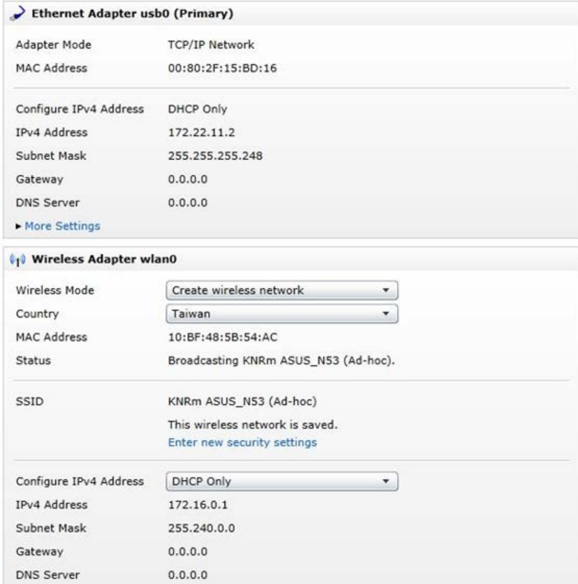


Fig. 1. Network configuration of KNR

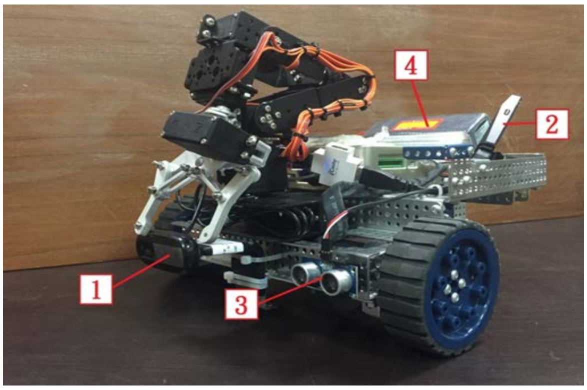


Fig. 2. The exterior of arm equipped exploring robot .

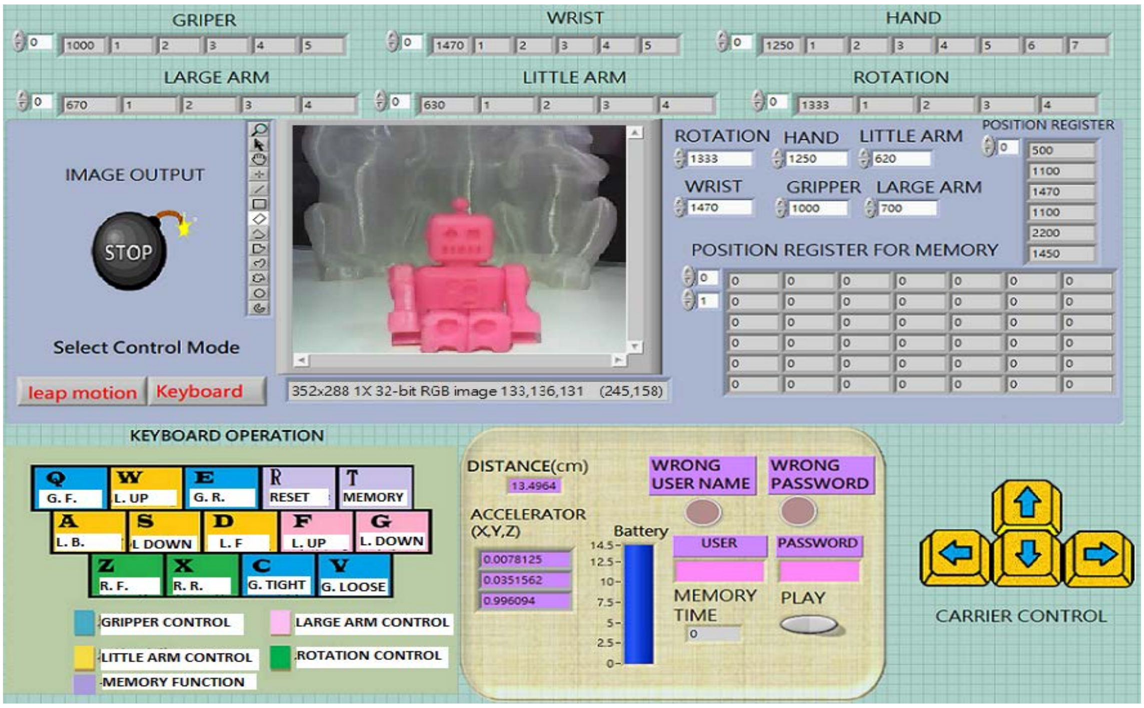


Fig. 3. The front panel of arm equipped exploring robot.

In addition to the KNR controller, external devices, including a (1) webcam, (2) Wi-Fi module, (3) ultrasonic distance sensor, and (4) Li-Po 14.8 VDC rechargeable lithium battery, are also equipped on the structure of the robot system in Fig. 2. Moreover, Leap Motion 3D controller is utilized for the gesture control function of the robot arm. The front panel of the arm-equipped exploring robot in Fig. 3 consists of four major parts to perform operations. The first part is for sign-in use. The second part is for displaying real-time images. The third part is for controlling the wheel carrier. The fourth part is for the robot arm control. The equipped robot arm possesses a six-axis operation and is driven by MG996R servomotors. Fig. 4 presents the control block flow diagram of the arm-equipped exploring robot, and the control functions consist of system sign in, robot arm control, instant webcam, and ultrasound distance sensor. Fig. 5 illustrates the control flow. In Fig. 5, the data transmission between computer server and KNR controller is wireless. In the computer server side, after sign in, all the sensing data and control functions will be displayed in the front panel as Fig. 3. Fig. 6 depicts that the system hierarchy is up to eight layers.

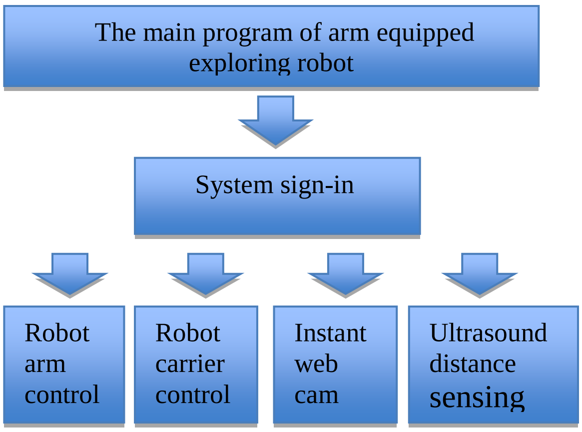


Fig. 4. The control block flow diagram of arm equipped exploring robot

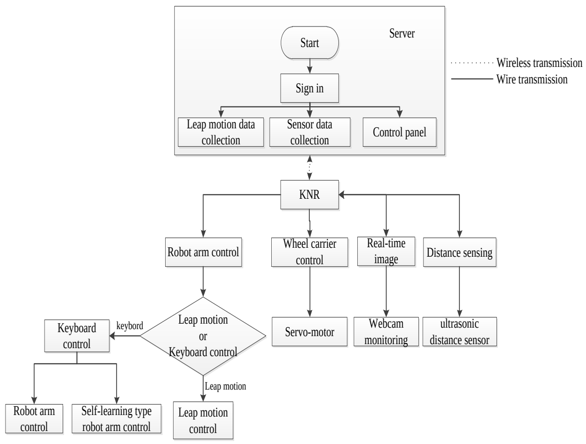


Fig. 5. Control flow of arm equipped exploring robot

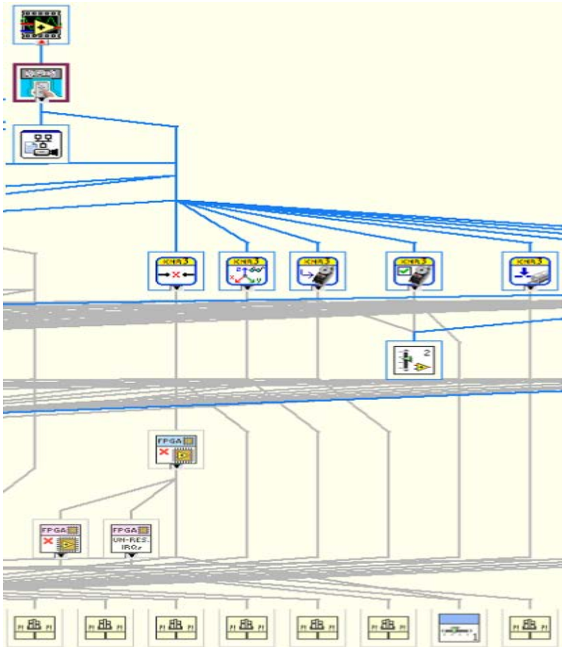


Fig. 6. The part of system hierarchy

Fig. 7 shows the block-diagram of the sign-in function. In this robot system, the robot can be operated by wireless control. For security purposes, the sign-in function is designed for protecting the robot system. The design idea of the program utilizes Sequence Structure to proceed the robot operation after the user name and password are verified through Match Pattern function.

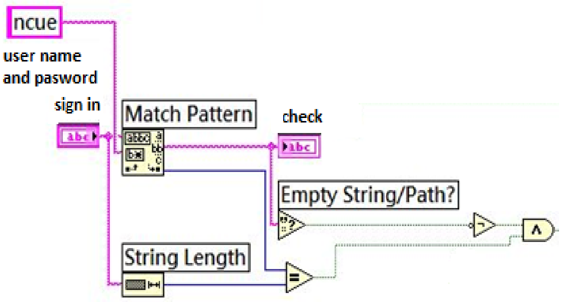


Fig. 7. The block-diagram of sign-in function.

Fig. 8 shows the sign-in test.. When the system is signed in with wrong user name or password, a pop out window will show to remind the user to try it again.

Fig. 8. The sign-in function test.

Fig. 9 displays the block-diagram of the instant webcam control. While Loop is used to perform the image acquisition continuously and Vision Acquisition is utilized to obtain real-time image.

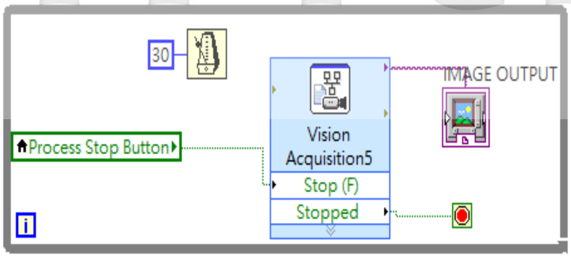
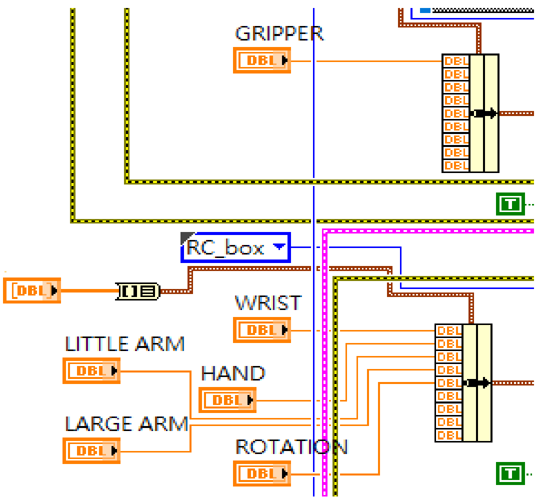


Fig. 9. The block-diagram of instant webcam control.

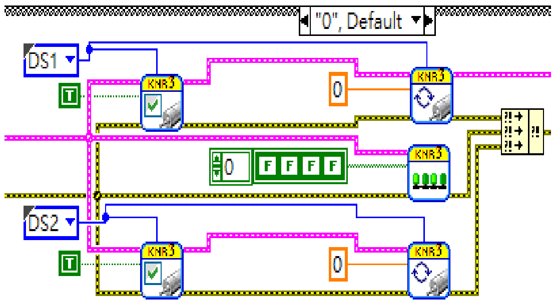
Fig. 10 shows the test of activating the webcam setting, 352X288 1X 32bit RGB image to display.

Fig. 10. The image of webcam test.

Fig. 11 presents the block-diagram of the motor control of the robot system. Fig. 11(a) contains the definition of order for six RC servomotors located on the robot arm. Fig. 11(b) consists of the wheel control for two DC motors. Furthermore, Fig. 11(c) contains the robot arm control of six RC servomotors.



(a)



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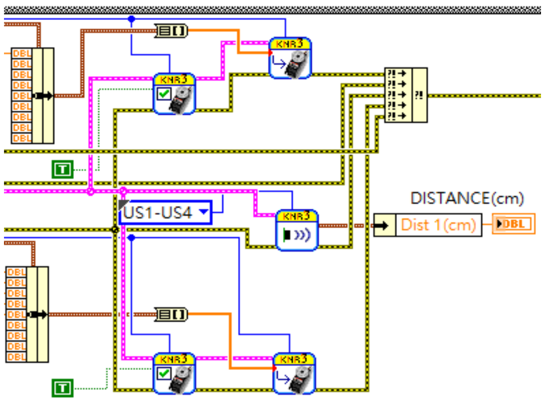
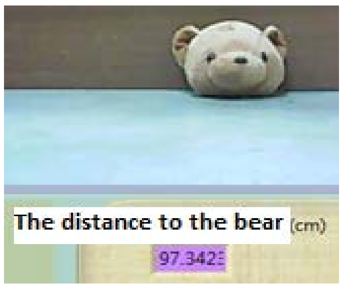


(c)

Fig. 11. The block-diagram of robot carrier control.

Fig. 12 shows the robot carrier control cooperated with ultrasonic distance sensor for distance sensing. In Fig 12(a), the distance between bear and robot is about 97 cm. In Fig 12(b), the distance between bear and robot is about 11 cm.

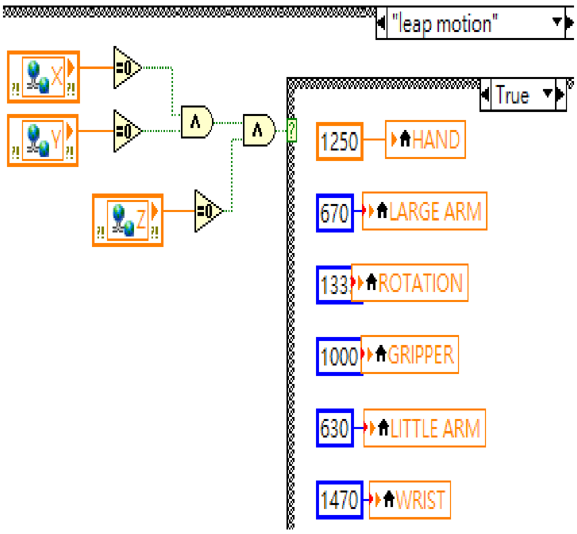


(a)

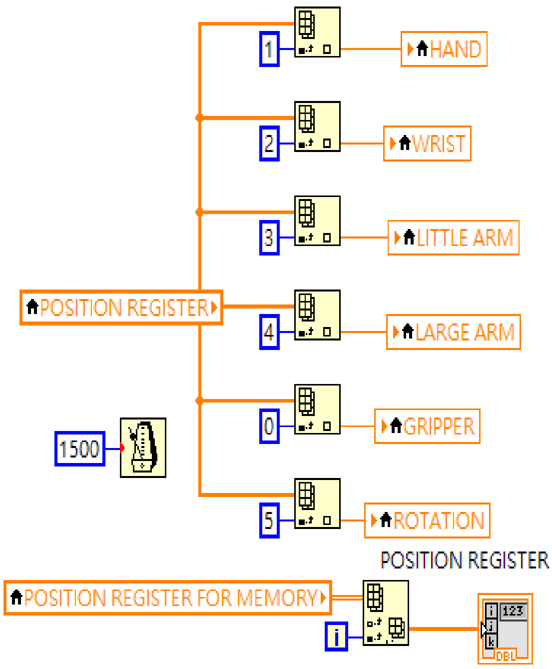
(b)

Fig. 12. (a) The robot stays a distance away from the bear.
(b) The robot moves close to the bear.

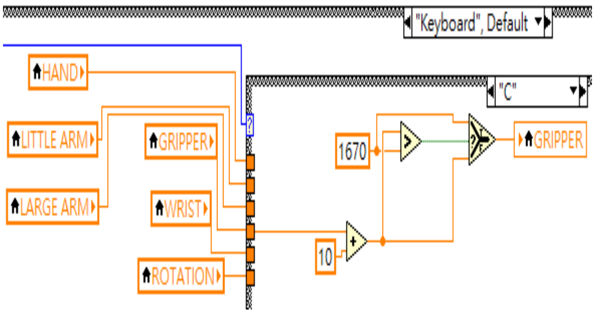
The robot arm can be controlled in three ways. The first is Leap Motion control. Fig. 13(a) displays the block diagram of the Leap Motion control function. The second is learning-mode control. Fig. 13(b) exhibits the block diagram of the learning-mode control function. In this robot system, the program of the learning-mode control of the robot arm can have seven moving paths to record and perform arm operation. The third is keyboard control. Fig. 13(c) shows the block diagram of the keyboard control function.



(a)



(b)



(c)

Fig. 13. (a)The block-diagram of the robot arm based on Leap Motion control.
(b)The block-diagram of the robot arm based on learning mode control.
(c)The block-diagram of the robot arm based on keyboard control.

CONCLUSIONS

In this research, NI KNR and LabVIEW are applied to design and construct an exploring robot with a wheel carrier and robot arm. The accomplishment tasks include software design and robot construction. Software and hardware integration allows this robot to possess the capabilities of vision, distance sensing, and wireless signal transmission. The robot arm can be controlled by a keyboard and Leap Motion sensor, and its processes can customize a number of arm positions, so that it can repeat movements. Moreover, these equipments are also used in the robot category in world skill competitions. Therefore, this developed robot can also be applied as teaching and training equipments for robot talent cultivating (Kai-chao, 2019).

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具機器手臂之輪型機器人

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摘 要

本研究以LabVIEW配合KNR實現具機器手臂之輪型機器人系統建置與應用，並在機器手臂控制上，並賦予不同的控制模式。此機器人系統所使用之感測器和手臂控制均由無線傳輸達到感測與控制之目的。此機器人結構上，具備攝影機、超音波感測器、鋰電池和無線傳輸之通用序列匯流排連接器，以達到即時影像擷取、距離偵測、電源供給和無線信號傳輸。機器手臂控制上，包含鍵盤控制模式和手勢體感控制模式，在鍵盤控制模式上，是蒐集鍵盤按鍵資料，透過Wi-Fi 無線傳輸到KNR做運算，再控制機器手臂與車體移動，於鍵盤控制模式下，還有一個學習功能，可自動定義數個手臂位置，讓機器手臂重複執行，使其具備手臂移動學習之功能。手勢體感控制模式是蒐集手勢體感控制器之訊號，透過Wi-Fi 無線傳輸到KNR 運算後，讓手臂執行模仿使用者手部運動之功能。