USE OF A RASPBERRY PI TO BUILT A PROTOTYPE WIRELESS CONTROL SYSTEM OF A MOBILE ROBOT

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Abstract: *The main aim of this article is to present the design and build wireless control system for the mobile robot with omnidirectional wheel. The system uses popular Raspberry Pi microcomputer with dedicated hardware and operator PC. The drive's control is supported by Arduino Mega 2560. The control application was developed using free software tool. The article presents the step by step guide to system configuration and startup.*

Keywords: Raspberry Pi, Mobile robot control system, Wireless mobile robot control system, Omnidierectional wheels.

1. Introduction

The design of mobile robots can be considered in terms of three of the most notable aspects: the way of moving, the transmission medium, the method of controlling a robot. The wheel drive that is most commonly used in robotics, allows very fast movement. Its simple structure makes it reliable and easy to control. Low drive's energy consumption follow a small rolling resistance. Because of these properties, wheeled mobile robots are cheap to build, operation and servicing. In the case of wheeled robots, an interesting solution is to use a special omnidirectional wheels in order to achieve an off-road platform, while reducing the resistance occurring in the system (relative to the track drive) and simplifying the structure (in the case of a drive with a pair of steered wheels). This solution is not without drawbacks. Robots using omnidirectional wheels are less efficient in the field and have worse traction on flat surfaces. The model of a robot equipped with omnidirectional wheels was designed based on the diagrams described in the literature and in the Internet (Panasiuk et al., 2015). Omnidirectional system allows the robot to move linearly forward, backward, right, left, at fixed angles and rotate in place. The Fig. 1 shows the CAD model and the real model.
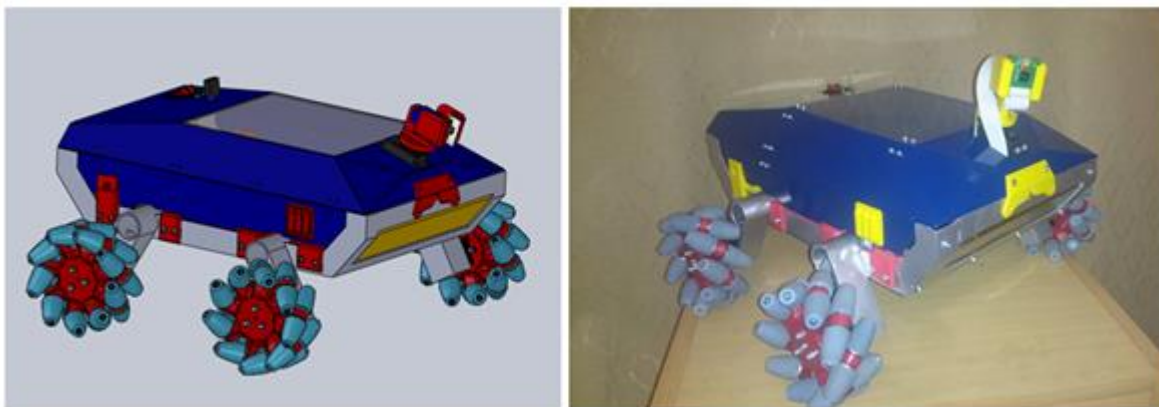
Fig. 1: CAD model and real model of mobile robot with omnidirectional wheels.

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The analysis of the mobile robots design indicates a huge versatility of control systems. Way data transfer control robot and feedback to the operator is one of the most important parts of the devices. Until recently it was believed that the use of wired connections is the safest, relatively inexpensive solution that provides the smallest transmission errors.. However, such solution limits significantly the possibilities of mobile robot. Attention should be paid to the technique of wireless communication.

2. Methods

When designing a control system for the mobile robot with omnidirectional wheels one should put the emphasis on the launching simplicity and low cost of construction. It should also be fairly easy to control such system from a PC. The developed system consist of wireless control system and video transmission based on Raspberry PI, HD camera (image source), Arduino Mega 2560 as a microcontroller implements driver control system and Windows PC with wireless network adapter (as operator PC)(Robotics forum Forbot). System is shown in Fig. 2.
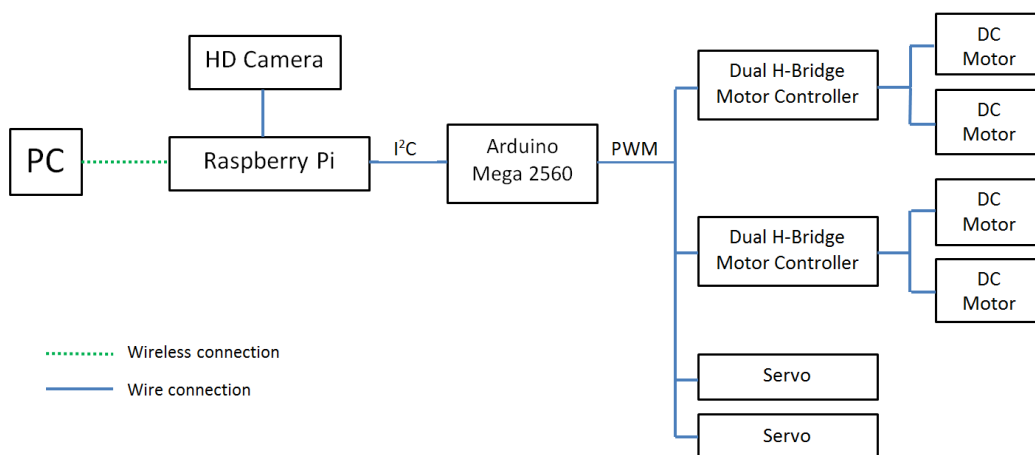

Fig. 2: Block diagram of the robot control system.

2.1. The hardware implementation

Raspberry Pi microcomputer in the B version is equipped with a 700 MHz processor and 512 MB RAM. SD cards up to 64GB are uses as data carriers This solution has reduced the weight of the Raspberry Pi board and the risk of failure associated with traditional hard disk. Raspberry Pi is equipped with basic connections and interfaces: two USB, Ethernet socket, SPI, I2C and UART. Linux-Raspbian is installed on the SD card. Electronics companies offer a variety of circuits used in vision system.

The choice of the camera was dictated by: minimalism, the possibility of quick implementation in system and the price. The module with the HD camera compatible with Raspberry Pi was chosen based on the aforementioned features. The camera is equipped with a 5 Mpx CCD matrix, which allows recording in 1080 p. The connection of the camera with Raspberry Pi is performed by connecting tape. The system installed in the memory of microcomputer supports selected camera module.

Due to the knowledge of the Wi-Fi communication between robot and PC built using this transmission standard. Among the many commercially available devices for wireless transmission of data chosen LB-LINK wireless network adapter. The adapter has a 150 Mbps transmission speed, frequency band 2.4 GHz and 17 dBm antenna power. The LB-LINK adapter is an extension dedicated to the Raspberry Pi and does not require installing additional drivers (Fried, 2013).

To obtain a full functionality, omnidirectional chassis requires four independent control signals used to control the drives. In addition, the projected vision system should rotational motion control of the camera. This task requires two independent PWM signal outputs. Raspberry Pi B is equipped with only one PWM signal output. Additionally, CPU resources will largely be used to support wireless communication and video streaming. Therefore, Arduino Mega 2560 equipped with ATmega microcontroller was selected as the drive control signals forming unit. Data transmission between Arduino and Raspberry Pi is done by I²C bus.

2.2. The software implementation

Implementation of the control system required the implementation of several tasks: connection of the operator PC to on- board robot computer, development of application that provides video streaming, development of application enabling drives control via Arduino.

The first step to configure of the Raspberry Pi as access point and create a robot network, to which the operator PC will be able to connect. To do this, after logging in connect LB-LINK adapter to the USB and Internet through Ethernet connector. Next step is to check LB-LINK adapter visibility in Raspbian using Linux command ifconfig –a and install the drivers for working Raspberry Pi as a DHCP server by typing in the terminal sudo nano apt-get install hostapd isc-dhcp-server. After driver installation open dhcp configuration file using command sudo nano /etc/dhcp.dhcpd.conf. Changes in the configuration file related settings would allow to obtain IP and DNS address, network mask and range of allocated IP addresses.

Next configuration steps to investigate the static IP address for the Raspberry Pi. It necessary to open another configuration file using the command sudo nano /etc/ network/interfaces and add information about the static IP address for connecting wlan0.

The final step of DHCP server configuration is to open the host configuration file using the command sudo nano /etc/hostapd/hostapd.conf and enter the name of the LB-LINK adapter driver, the network name, password and other network parameters. After properly configuring the network, rebooting Raspbian, the robot Wi-Fi was visible in the networks available on PC. The wireless connection robot-operator PC was implemented by the SSH protocol, which is a communication protocol used in TCP/IP for terminal connection to the computer. SSH works in client- server architecture on default port 22. To connect operator PC to the on-board robot computer uses the popular and free software PuTTY, which is a client in network connections. After downloading and installing the software on operator PC the first step was to connect with the local robot Wi-Fi. Then, in the PuTTY address field one should enter robot IP address (Fig. 5, no. 1) , select the port number (Fig. 5, no. 2), and communication protocol type (Fig. 5, no. 3). The program also allows to enter the name of configuration (Fig. 5, no. 4). After initializing the connection by pressing Open, the terminal appeared from which one can log in to Raspbian and start video streaming and robot control application (Engst, 2003, Sosna, 2008 and Fried, 2013).

Wireless communication control application is written in Python using the available in Raspbian development environment Geany (Sosna, 2008). The application allows to control the movements of a robot, robot speed and rotation of the head with a camera using the PC keyboard. Pressing a key starts the algorithm checking the binary code key pressed. When the control key is pressed- the algorithm processes the information in accordance with the assigned function key, forms a control data frame and sends to the ATmega microcontroller by I^2C bus. The microcontroller encodes frame and forms PWM drives control signal according to the received information.
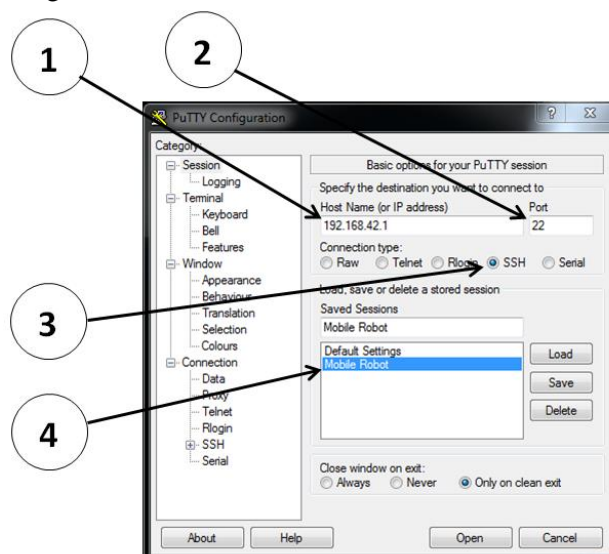

Fig. 3: PuTTY configuration window.

Video streaming was realized by running on the computer raspberry Pi server sends video data (Robotics forum Forbot). This task uses the *vlc* library, which was downloaded and installed on the Raspberry Pi as an additional package. To start the video streaming one should open another terminal window, log in to Raspbian and enter the *raspivid* command with appropriate parameters of streaming. Once so configured video streaming operator can preview the data on VLC Media Player installed on PC, running option program *Open Network Stream…* and typing the IP address of the on-board robot computer. The view of the operator PC screen with open application shown in the Fig. 4.

Fig. 4: Operator PC screen.

3. Conclusions

The result of the work is universal control system for mobile platforms. The user can set it up and adapt to any design of mobile robot. This solution allows for quick and cheap start prototype of the mobile robot to check its functional and driving parameters. Tests of the control system have shown that the video streaming has a 1.5 s delay, and control data transmission has 1s delay. Transmission range in open space is 55 m, in a confined space 40 m. Designated transmission parameters are imposed by the capabilities of Raspberry Pi. At the stage of construction of the control system shown in this paper, the security issues was not considered. The main problem is loss of the control and in this case robot stops. Reliability issues of the robot control system will be resolved at next stage of project development.

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