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Wireless Mobile Robot Control With Tablet Computer

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Abstract

In this study, a mobile robot carrying an on board camera is designed and implemented, which can be controlled remotely with wireless technology. Android operating system based tablet computers (controller) control mobile robot remotely and one android interface program is designed for remote control. Mobile robot is a microcontroller based embedded system and its hardware works on Linux operating system. Mobile robot and controller communicate with Wi-Fi (Wireless Fidelity) communication (socket communication). Mobile robot’s camera takes video continuously and sends it to controller screen. These video contents are examined by the controller user; speed and direction information are entered from touch screen and these information are sent to mobile robot. In this manner, mobile robot movement is provided. Mobile robot motion is handled by direct current (DC) motors controlling and it is achieved with Pulse Width Modulation (PWM) method. System consists of two interrelated systems. One interrelated system is mobile robot part and the other is controller part. Mobile robot works as a server and controller works as a client. Observed video, which are taking from on board web camera, send from server to client wirelessly. Client takes video and shows it on screen. User can control the mobile robot by setting direction and speed from android tablet. Entered information sent to server and server sets motion parameters by using this information. Real-time video transportation is achieved with Motion Joint Photographic Experts Group (MJPEG) on Linux operating system. Because of the system performance, captured video is not saved. In client side (controller), speed is arranged 0 to 100 and for motion, user can set direction to left, right and direct. On controller application screen, user can see entered speed and direction values by the animated images.

Keywords: Android; Socket Communication; Wireless Communication; Pwm; Mjpeg

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1. Introduction

Smart systems are improving rapidly nowadays. This improving set of different control systems designs and using in our daily life. In the beginning, inventions and designs were achieved only one special need, but now more functions are coming together and more works are achieving. Thus, embedded systems begin to appear in our lives. Both of the academic and industrial areas invest in embedded systems constantly. Scientists, researchers and academics, who work in embedded systems, bring new works in our World.

In this study, a sample wireless mobile system, which is controlled remotely, is achieved. This system can be controlled any of the android operating system devices, in the event of device operating system version is suitable. In mobile robot part, using operating system is Linux and the processor is ARM (Acorn RISC (Reduced Instruction Set Computing) Machine) CPU (Central Processing Unit). Additionally, all of the control information’s take from touch screen of the controller (client) and the data, which is consists of only motion information, is send to mobile robot (server). Touch screen using brings ease of use and users don’t need to spent more money for any hardware devices. They can use their own android mobile devices.

In server side, receiving image format is MJPEG. MJPEG is abbreviation of “Motion Joint Photographic Expert Group”. MJPEG is a video compression format in multimedia. Each video frame or interlaced field of a digital video sequence is compressed separately as a JPEG (Joint Photographic Expert Group) image. Originally developed for multimedia PC (Personal Computer) applications, MJPEG is now used by video-capture devices such as digital cameras, IP (internet protocol) cameras, and webcams; and by non-linear video editing systems. Because of reducing the coding time and improving system efficiency, MJPEG video compression format is used in this study.

This system area of the usage is wide. In some of the natural disaster (such as earthquake, landslide, subsidence), this system can be used for protecting people lives or in consideration of people physical situations. For reducing security cameras’ cost, labor, upkeep expenses; this system can be used in houses, offices, and factories for security reason. Users can check their houses from their android operating system devices in spite of fire, water flood or robbery, when they are out their houses. More than one user can use this system from own android operating system devices. This increases the system effectiveness.

2. Literature Review And Hypotheses

Technological developments improve very fast in embedded systems world. This study differences should be explained clearly for isolating from other studies. In reference (Eristi, 2009), taking wireless video was analyzed with some image processing techniques in computer and quantity of motion was calculated on computer. In another study (Yigiter, 2010), control was achieved on computer and different sensors were used; PIC (Peripheral Interface Controller) microcontroller was used. In reference (Onal, 2011), a mobile device was controlled radio frequency (RF) communication from computer and PIC microcontroller was used on mobile device.

A mobile robot design was realized to find underground objects for obtaining three-dimensional space (3-D) imaging in reference (Kizilhan, 2010). One another embedded systems’ mobile robot design was achieved in reference (Comlekciler, 2009). Video and image streaming on embedded systems over wireless communication protocol study was achieved for transmitting to projection device in smart class projects (Ilhan, 2012).

Mobile technology improvements make people lives very easy. People can control some devices and tools from their smart devices, computers vs. remotely far from kilometers away than controlled device. Nowadays, farmers can water their greenhouses on mobile phones remotely. People can learn so much information about their houses situation from smart house systems, when they are far from the houses. Users can control white goods, which they use at house. User can see white goods program status or give some commands from his/her suit. In this study, one wireless controlled mobile system is achieved.
This system helps people in dangerous areas. For example, if one unknown package realizes and no one wants to check the package, user can use this mobile robot. Mobile robot takes video and sent information to controller. User also can direct the mobile robot motion. Mobile robot can be used in natural disaster area. Sometimes, in salvage work, nobody can access the risky places and they don’t have any idea they are right coordination. Using this study mobile robot, they can check the place easily and safely. In big factories or offices, managers prefer some security cameras in different locations. This security precaution is expensive. Because it needs lots of hardware and this means extra money. So much labor is wasted during its maintenance. If this system is used, only wireless communication is enough. Whenever a user wants to check any place, user manages the mobile robot from own android operating system’s mobile device. This study using areas are wide. Its usage is easy and users can not need to carry any extra control hardware together. Controller part can be any android operating system device. System mobile robot parts use open source operating system and this reduces the system cost. Two parts communication protocol is Wi-Fi and nowadays Wi-Fi using is widely.

3. Methodology

3.1. Research Goal

This system helps people in dangerous area, where life and property loss probability is high. Such like this kind of situations, more securely information can be taken. One another aim is, reducing some expenses in offices, factories, vs. Users can use an easy and cheaper security system in the houses. In this study, a mobile robot carrying an on board camera is designed and implemented, which can be controlled remotely with wireless technology. Implemented system can be used different platform for different aims. Some of the application areas are given in literature review and hypotheses part. All system is consists of two interrelated parts. One is controller part and the other is mobile robot part. Controller part highlights are easy usage, portability and to keep cost down. Mobile robot part is more complex than controller part. It is based on an open source operating system and this reduces the system cost. It carries an on board camera and communicate the controller via Wi-Fi.

3.2. System

The system is consists of mobile robot part and controller part. These two parts communicate each other wirelessly. When the system starts, mobile robot begins to prepare its own system. System prepare camera and begin to wait command from controller. Controller begins to work, when the application starts. More information about these two parts will be explained in the following sections.

3.2.1. Mobile Robot

This part is system movable part. In this part, Raspberry Pi is mobile robot brain. The Raspberry Pi is low cost, credit card-sized single board embedded system card. It has ARM processor and it uses Linux operating system. This part is called “Robot” from now on. The system block diagram can be seen in figure 1. After start, system begins to work. Then, the other components can be separated in three main parts. They are:

- Battery and its components
- Motor driver part
- Raspberry Pi part

Battery and its components part ensure power to all the system. Motor driver part provides system motion. Raspberry Pi works as a brain in the system. It has a camera, which takes video and Raspberry Pi send the video to controller. Raspberry Pi takes motion commands from controller via Wi-Fi and sends the motion data to motors.
Two of the Raspberry Pi general purpose input/output (GPIO) pins set as PWM pins. They are using for motion. Four of the GPIO pins are using for forward and backward motion of the robot. These two pins belong to one motor backward-forward motion and the other two pins belong to second motor. Totally, six GPIO pins are used for robot movement. L293D motor driver integrated is used in motor driver circuit. Mobile robot part circuit design illustration is given in Figure 2. All connection can be seen on this figure.

Socket communication is used between robot and controller. Robot part works as a server and controller works as a client. After start, server begins to wait connection information from client. Server stays on wait stage so long as no connection information comes. Direction and speed information data come between connection information from
client. System movement can be performed coming information from controller (Perkins, 2003), (Chen & Zhang, 2004).

3.2.2. Controller

Controller communicates with robot via Wi-Fi and controls its movements. Controller works on Android operating system devices, such as mobile phones, tablets, android computers and using controller device should support Wi-Fi. One application runs on controller device. When user opens the application, it begins to work.
Controller takes video from client (robot) and shows the video on its screen. It also takes direction and speed information from touch-screen touches and sends the significant data to server. Controller also process touch-screen information and then sends the data. The controller system physical working illustration is shown in figure 3. Figure 3 is a block diagram of the controller in fact. It is created thinking to application items locations.

In the application, video is places all the screen. Direction is taken from the left side of the touch-screen and speed is taken from the right side of the touch-screen. Direction is changed finger position changing from left to right. There is also a separated area for direct motion between these two directions. This area left side is for left rotation and right side is for right rotation. For direction changing, one steering wheel image is used in the application. It rotates according to direction situation.

Speed is changed bottom to top in the right side of the touch-screen, but screen is divided two for backward and forward movements. One throttle image is used for speed screening. In the middle of the speed area is zero position. If finger position is changed from zero position to top, robot drives forward. If finger position is changed from zero position to bottom, robot drives backward. One sample screen coordinate axis placing is presented in figure 4 for controller. Controller application is designed on android platform and using programming language is java (Felker, 2011), (Conder & Darcey, 2011), (Friesen, 2010), (Gargenta, 2011), (Burnette, 2008), (Meier, 2009).

3.2.3. Mobile Robot Motion Calculations

In this system, two motors speed arrangements is adjusted in controller part according to direction and necessary information send to mobile robot. There are two motors in mobile robot part, one is left side of the robot and the other is right side of the robot. When the robot drives directly, coming speed values are used. In turn to right and turn to left calculations, speed arrangements are a little different. Turn to right and turn to left arrangements is completed with below equations. These equations are used in algorithm of the system program.
For left motor:

- If user wants to turn right, the motor speed value is accepted the same with the coming speed value.

\[ v_{\text{left}} = v \]  

(1)

- If user wants to turn left, the motor speed value is given in equation (2).

\[ v_{\text{left}} = v - \frac{v \times (-1 \times d)}{100} \]  

(2)

For right motor:

- If user wants to turn left, the motor speed value is accepted the same with the coming speed value.

\[ v_{\text{right}} = v \]  

(3)

- If user wants to turn right, the motor speed value is given in equation (4).

\[ v_{\text{right}} = v - \frac{v \times d}{100} \]  

(4)

In the above equations, abbreviations mean:

- \( d \): direction, \( v \): speed, \( v_{\text{right}} \): right motor speed, \( v_{\text{left}} \): left motor speed

3.2.4. Simulation of the System

One simulation environment is created for realizing the system. For this reason, one simple work environment is prepared for controlling all of the works. Robot and controller communicate each other via network. They need to connect one network for this aim. In this system, both of the robot and controller connect to router for realization. In this connection, robot takes one permanent IP (Internet Protocol) address. By this means, controller can reach the robot and socket communication is set between controller and robot. In figure 5, one representational image can be seen.

Mobile robot begins to work after start. When the robot completes its opening operations, camera begins to work and PWM part begins to wait commands from controller. In this stage, server begins to wait client communication. In controller part, when the application starts, controller takes video from robot and shows video on its touch-screen. At the beginning, robot part is static. When the speed and direction info come from controller, robot begins to drive. Speed and direction info takes from user via the touch-screen. Both of the mobile robot and controller application image can be seen in figure 6.
Fig. 5. Representational communication image

Fig. 6. (a) All system photograph with camera scene, (b) controller and mobile robot photograph from above
4. Conclusion

This system is designed for thinking human physical condition and human safety. Because of the human physical conditions, people could not arrive some places. This system can work this kind of areas. For safety, people can set some security cameras in different places. Setting one camera system is expensive, labor and maintenance expenses are high. This system is cheaper than a camera system and user can access the system whenever they want to use.

One of the biggest differences of the system is that, system can work any of the android operating system platforms and users can use their own devices. Additionally, more than one user can use the system remotely. One of the other important point is, mobile robot works on one Linux operating system platform.

Performing system can use in search and rescue works, in living places (houses, offices, factories, etc.). Cause of the easy usage, this system can be used different areas. This system can be adapted in flying or climbing systems in the future works. By this means, system usage areas are increased.

References