

Wireless Controlled Surveillance Mobile Robot through a Customized Web-User Interface

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Abstract

Objectives: The present work focuses on tele operated mobile robot with wireless control through the customized web user interface to ensure the knowledge about the environment by live video surveillance. **Methods/Statistical Analysis:** Live video streaming is provided through the browser that allows the user to manipulate the robot from the comfort of a web interface. Streaming of surveillance is received and viewed on a remote desktop or even a mobile phone. Robot wheel motor is interfaced with the server using Raspberry Pi. Data is collected from the sensor and the onboard camera and stored in the database for analysis. **Findings:** The main feature of this robot is its all-terrain capabilities with rugged construction give the vehicle a high payload torque and multi terrain capabilities. Live streaming from all-terrain vehicle gives the user a visual interface which gives more knowledge about the environment so that the user can make decisions. Moreover, the user can control the vehicle and its direction from a web-browser interface. The user experience is mainly focused in this paper and if the user makes an error which is harmful for the vehicle an override algorithm is used to overcome the user input. **Applications/Improvements:** This paper was designed for the application of mobile robot in the field of military applications such as live video surveillance and robot navigation.

Keywords: All-Terrain Vehicle, Mobile Robot, Raspberry Pi, Web-User Interface, Wireless Camera

1. Introduction

The robot designed for the current study will focus on special applications like military and industrial purpose with special attention to use wireless camera which is used for surveillance application constantly monitors the location¹. The existing system includes surveillance of indoor environment such as airports and museum, building maintenance and monitoring of safety equipment². The concept of supervisory control can also be used to perform exploration of scarcely known or unknown environments³. But in the current study the robot is constructed with wireless control through customized web user interface. It is also possible to control the vehicle using mobile devices and it can be used for rescue operation⁴. The wireless controlled surveillance robot is specially designed to enter in risky zones without its surroundings being mindful of its vicinity⁵. Approaching towards the next level of technology the autonomous mobile robot can be used

for wireless position tracking using GPS and sending that information on to a device such as mobiles, tablets etc⁶. Nowadays, mobile robots are used in military applications for surveillance over the border security and access multi tasks to visual interface, robot navigation and collecting the sensory data to acquaint quick and efficient information about the environment. The robot controlled via internet also be a specific application by increasing the area it surveys⁷. The advanced design and development of robotic technology focuses on the control of mobile robot by using GUI as navigation control⁸. Often the control module used for controlling the robot usually based on radio signal transmission. These transmission systems require custom made robotics platform and controllers as well as radio signals which are not secure and extremely vulnerable. To prevent such interceptions, it is necessary to establish a secured connection and should only be accessible by authorized personnel. The tele operated robot which operates only on Wi-Fi can also be controlled through local network or internet⁹. In addition to the live

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video streaming, PIR sensors can also be used to detect the living bodies in an unknown environment controlled with the internet¹⁰.

2. System Overview

The overview of the tele operated mobile robot system is depicted in the Figure1. It is a closed loop system with the user that gives the functional relationship among the various parts of the system. The microcomputer that is embedded in the robot can access the internet through the wi-fi adapter. The command inputs given by the user are to be understood by the microcomputer and it has to generate the necessary action. At the same instant, it transmits the local live video for the user to monitor the surroundings, observe the robot status and manipulate the robot through the web interface.

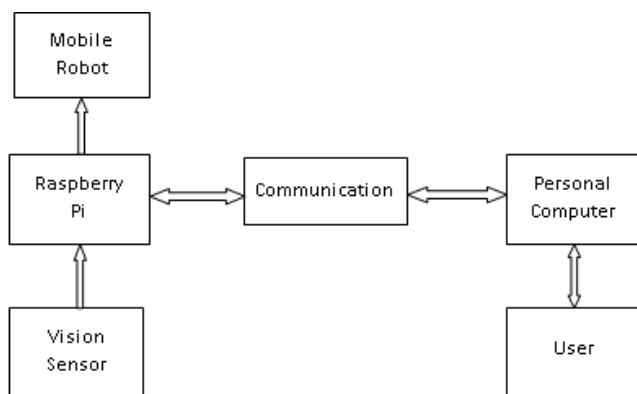


Figure 1. Overview of tele operated mobile robot.

A webpage is configured that forms the user interface for manipulating the robot. The personal computer is installed with the remote desktop tool to make any modification of control program in the Raspberry Pi and also for communication between the user and robot. The vision sensor gives the visual feedback of the environment to the user through microcomputer.

3. Mechanical Design

The construction of the mobile robot is to achieve all-terrain inspection capability, the chassis should be both less in weight and at the same time it should be sturdy. The length and width of the parts are as shown in the Table 1.

Table 1. Measurements of the Parts

Sl. No.	Parts	Length	Width
	Chamber 1	300 mm	110 mm
	Chamber 2	300 mm	110 mm
	Separation (Pivot)	Separation of about 30 mm	

The Figure 2 shows the Aluminium plates of thickness 1.5 mm are chosen to build the chassis of the robot as it satisfies this state. According to the dimensions were taken, with the help of bending press machine the plates were bent into a chamber of 300mm x 110mm x 50mm.



Figure 2. Aluminium Plate Thickness.

The Figure 3 shows the arc welded aluminium plate which is used to tact the chamber at a 90 degree angle. L clamps with custom made holes are used in order to mount the motor to the chassis. A 10 mm hole was drilled through the chassis on the inner side. An aluminium bush of 25 mm diameter was welded around the 10 mm hole in the center. The bush was to separate the two pieces of chassis and hold them at a distance of 30 mm.



Figure 3. Arc welded aluminium plate.

A M10 nut and bolt setup was used to join the two pieces of chassis to make a center pivot mechanism. A 6mm milling cutter was used to do key way slotting.

The key slotting was to accommodate the wheel hubs. The ground clearance of the robot is 4 cm. The robot chassis arrangement is symmetric which gives the robot an ability to travel on both sides even when it is flipped over. The ground clearance in such scenario remains the same. The robot has an ability of climbing a 25-degree angle inclination. The weight of the robot is measured to be around 3kg.

3.1 Pivot Mechanism

The pivot mechanism at the center is one of the salient features of the robot. This ensures that the left and right portions of the chassis can be completely independent of motion relative to each other. This allows greater flexibility while travelling in an all-terrain environment. If in case a tire gets stuck in an all-terrain environment, it is hard for the vehicle to move in most of the cases. The reason for the vehicle getting stuck is that the wheels are at different levels. This problem can be eliminated by central pivot mechanism. This will allow the other three wheels to spin irrespective of the one other wheel.

3.2 Components Specification

3.2.1 All Terrain Wheel

The Figure 4 shows the all-terrain wheel which is used to give the robot maximum ground clearance. The bungee type of wheels used has a diameter of 120mm and a width of 60mm.



Figure 4. All terrain wheel.

3.2.2 D.C Motor along with Wheel Mount

The D.C motor along with wheel mount is as shown in the Figure 5 which gives the excessive amount torque to the mobile robot. The maximum torque of the motor used here is 18 kgf-cm torques per motor. It gives the vehicle a 36 kgf-cm torque capacity. The motor rotates at a nominal speed of 600 rpm.



Figure 5. D.C. motor with wheel mount.

Minimum Load current of the motor is rated at 800 mA at no load, while the maximum load current is rated at 7.5 A. The voltage of the motor is 12 volts.

4. Electronic Control Unit

In any Robotics system, the tight integration between the hardware and software ensures the successful functioning of the system. The electronic control unit consists of the motor controller, Raspberry Pi Microcomputer, Motors, Camera and power supply.

4.1 4Raspberry Pi

The Raspberry Pi computer used in this model is the Raspberry Pi Model B+. The Raspberry Pi B+ computer has a 512MB RAM. The operating system used is Rasbianoperating system. Micro SD was used directly to burn the disc image of the operating system into the SD card. The disc imaging facility used is WinRar32 disk imager. The Figure 6 shown below represents the Raspberry Pi Model B+. A 16 GB class 10 micro SD card is used in this system. This means that the microcomputer has a 12 GB Read Only Memory.

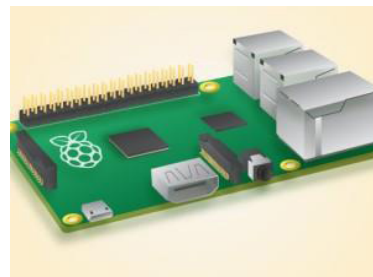


Figure 6. Raspberry Pi model B+.

The microcomputer also has 4 USB ports and an Audio Video In (AVI) port. The board also supports a HDMI cable interface and has a suitable provision.

Raspberry Pi has GPIO pins which are better known as General Purpose Input Output pins. There are 40 pins in the Raspberry Pi B+ model of which 26 pins are GPIO pins and the other pins are GND pins. Logic pins with 5 volt outputs and other logic pins with 3.3 volt outputs.

4.2 Motor Controller

Generally, there are a variety of motor controllers that are commonly available and most often used like L293d and L298. It is also possible to control the motor in both the directions using relay module. The four channel relay boards as shown in Figure 7 are used in order to control four motors. These relay boards used are opto-isolated. Opto-isolation ensures that the input pins in the relay, when connected to the GPIO pins in the Raspberry Pi are logically connected, but not electrically connected. This ensures that the Raspberry Pi is not affected by any current backflow when the motors operate.

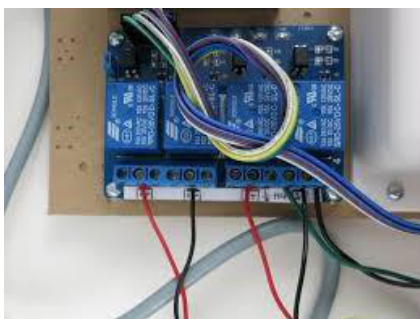


Figure 7. Four channel relay board.

4.3 Power Management System

The power management system for the surveillance robot consists of 2 different power sources. A 12V, 2.1Ah rechargeable Lead-Acid battery is used to provide power for all the four motors. This is connected as a source to the relay boards that are used to drive the motors. A separate source is used to power the Raspberry Pi processor board because its current limit is in-between 1000mA to 1500mA with an operating voltage of 5V. A 5V, 5200mAh portable charger is chosen such that the Raspberry Pi can operate for a long time.

4.4 Vision System

The main objective of this system shown in Figure 8 is for surveillance which can be accomplished by using a

vision sensor. In this regard a web camera is interfaced with the Raspberry Pi and mounted on the mobile robot. This provides the live video stream of the surrounding environment from the robot through the Wireless networks.



Figure 8. Vision System.

5. System Software

5.1 Making Raspberry pi as a Webserver

The interesting aspect is making the Raspberry Pi a webserver. A web server is a combination of client/server model and Hyper Text Transfer Protocol serves the files that form web pages to web users. Apache and Microsoft's Internet Information server are the two widely used web servers. Among these Apache is the most widely used server. In the present study Apache is used as a web server. After installation, the web server is used to create a website through HTTP server protocol and it can be accessed by typing the IP address of the Raspberry Pi onto the web browser.

5.2 Steps Involved in Installing Apache Webserver

The following steps are to be followed in installing the Apache web server in the Raspberry Pi.

- The Linux terminal was opened in the Raspberry Pi and the command `sudo apt-get install apache2 -y` command was used.
- By default, Apache puts a test HTML file in the web folder. This default web page is served when you browse to `http://localhost/` on the Pi itself or `http://192.168.1.10` (whatever the Pi's IP address is) from another computer on the network.
- To find the Pi's IP address, type `hostname -I` at the command line (or read more about finding your IP address). Browse to the default web page either on the

Pi or from another computer. The default webpage after installing apache server is as shown in the Figure 9.



Figure 9. Default web page.

5.3 PHP – Hypertext Preprocessor

PHP (recursive acronym for PHP: Hypertext Preprocessor) is a widely-used open source general-purpose scripting language that is especially suited for web development and can be embedded into HTML.

5.3.1 Installing PHP in Raspberry Pi

- Open the Linux kernel terminal in the Raspberry Pi and type the following command: *sudo*
- *apt-get install php5 libapache2-mod-php5 -y*.
- Now the website can be created using PHP and the necessary changes are made in the *index.html* file.

5.4 Accessing Raspberry Pi from another Computer

The Remote desktop function in the windows computer is a very useful function. Using this option one can remotely access a computer which is connected to the same internet connection. In this case the devices share the same wireless connection. The IP address of the Raspberry Pi is entered in the remote desktop environment and connection is made. The remote desktop environment is shown in the Figure 10. To access the Raspberry Pi from the remote desktop environment, one has to install the *xrdp* setup in it. This gives the user the permission to enter the username and password of the raspberry pi from another computer. Otherwise, the remote desktop connection fails and the Raspberry Pi does not allow connection. To install the *xrdp* type the command *sudo apt-get install xrdp* in the Linux kernel terminal.

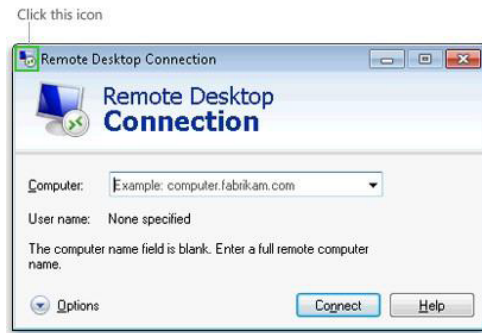


Figure 10. Remote desktop screen shot.

5.5 Installing the Wiring Pi Library

The GPIO or General Purpose Input Output pins of Raspberry Pi are used to control the relays which are used drive to the motors. It is easy to use python to access the GPIO pins through the Linux kernel terminal, but it is not that easy to do the same through a website. However, when trying to control the motors from a web interface, command has to be written and read using PHP script. Wiring Pi helps the user to use PHP commands to turn the pins into Inputs and Outputs.

5.5.1 Installing and Setting up Wiring Pi

The Wiring Pi can be installed by using the command *sudo apt-get install git-core* in the Linux kernel terminal. After using the command these steps have to be followed:

- Get the wiring pi library by using this command *\$ git clone git://git.drogon.net/wiringPi*.
- Change to the new directory, and get the code from the repository at drogon.net by using commands *\$ cd wiringPi*, *\$ git pull origin*
- Finally to build the code, *./build* command is used.
- Once the library is installed, one can use the command *gpioreadall* to read the pins of the Raspberry Pi.

The above command would generate the map of the Raspberry Pi pins in the kernel terminal.

5.6 Motion Library

The motion library is a library which is used for video streaming. This library contains instructions which are

responsible for starting a camera and stopping a camera. This also helps us to play a live video feed over a designated port in the IP address.

5.6.1 Installing the Motion Library

The Linux terminal screen shot is shown in Figure 11. To install the motion library, one has to use the command `sudo apt-get install motion`. The files will be installed and once this gets over, one has to configure the settings of the motion library. This is done as follows:

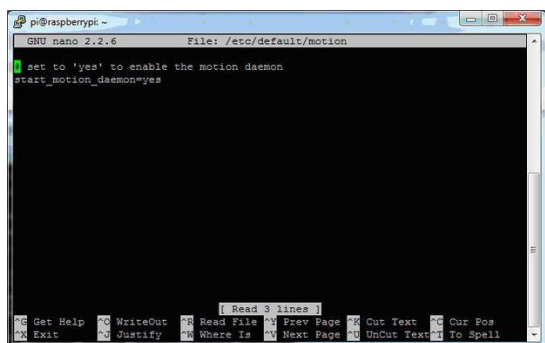


Figure 11. Linux terminal screen shot.

- First we will edit the motion.conf file by typing: `$ sudo nano /etc/motion/motion.conf`
- This is quite a large conf file but the points you need to edit are: `DAEMON = OFF (change to ON)` `Webcam_localhost = ON (Change to OFF)`
- Next we need to enable the Daemon (service): This is as shown above in the picture. `$ sudo nano /etc/default/motion` `start_motion_daemon = no (change to yes)`
- Other settings like resolution, frame rate, can be set as per the user requirement. This is in line with the application requirements.

5.7 Accessing the Website and Controlling the Robot

To access the website, switch on the raspberry pi and ensure that it is connected to a wireless network. Ensure that laptop or any other computer be connected to the same wireless network. Enter the Raspberry Pi's IP address on the browser to get a dialog box to start the motors.

After this a website with video streaming on the left and controls for controlling the robot on the right appears.

One can start navigation using these controls. The screen shots of the dialog box to run the motor and navigation control for robot is as shown in the Figure 12.

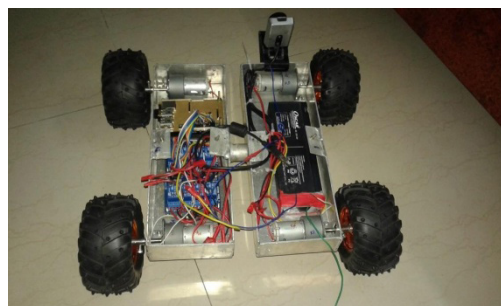


Figure 12. Dialog box to run the motor and navigation control for robot.

6. Conclusion and Future Enhancement

The overall design of the surveillance robot is as shown in the Figure 13. The robot was successfully integrated and the control of the robot through the website was tested. Its all-terrain capabilities and total run time were also tested during various trials. Based on these results the following conclusion have been made in mechanical and electronics section.

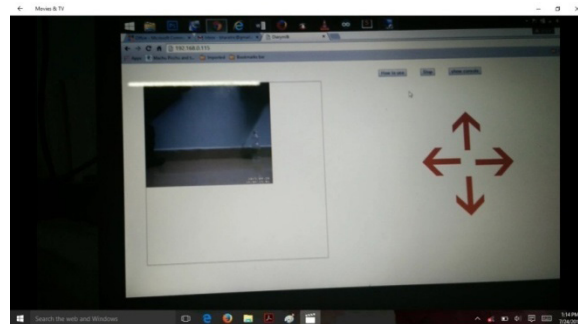


Figure 13. Overall design of surveillance robot.

(1) Mechanical section

Totally three chassis are designed in order to finalize on the current chassis. The main focus is for a chassis which was not very heavy and at the same time very flexible for manipulating through hard terrain.

(2) Electronics section

For driving a motor L298N is used for smooth operation.

But often the raspberry pi used would stop working for many times it never switched on again. On further investigation it was found that the motor produces 800mA current at no load condition and about 7.5A at full load conditions. The current produced from motor has been responsible for burning the Raspberry Pi board. The reason is that the L298N motor driver is used to handle current only up to 2mA. So, when the motor was running at a very high speed, there was current flowing at a greater limit. So it burnt the raspberry pi in its ground and power supply terminals. A solution was found by using a relay setup for controlling the direction of motors. These relays can handle the motors up to 10A at 30V DC. The relay is also opto-isolated and this would ensure that the inputs of the relay are logically connected to the Raspberry Pi's GPIO but not with any electrical connections.

6.1 Future Enhancement

Based on the design and fabrication of Tele operated Robot the various plans which are used to improve the robot in future is:

- By changing the Lead Acid Battery to Lithium Polymer battery. This would be used to reduce the weight of the power source by 500gm for a 2.2 Amp source.
 - The off road capability of the vehicle can be improved by using high torque producing motors.
 - In the current study a problem is noticed that while testing the vehicle, a hotspot setup that paired with raspberry pi and laptop gave a speed of 2.5 to 3.0 Mbps. So, there was some amount of lag while controlling the vehicle. This lag can be eliminated by using a portable and powerful wireless source.
 - Instead of using a normal webcam an Infra-red camera would allow a clear navigation in the night time also.
- The Raspberry Pi will be upgraded to Raspberry Pi 2 from B+ which would give an Arm7 based platform.

7. References

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