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IMPLEMENTATION OF MULTI-UTILITY ROBOTIC VEHICLE USING RASPBERRY PI

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***Abstract*—The Raspberry Pi is a low cost single-board computer which has recently become very popular. In this paper an attempt is made to build a low cost stand-alone device which transmits data using the Raspberry Pi which is acting as a web server. The main aim of this project is to develop a robotic that has multiple functions with the help of the Raspberry Pi. The robot is designed to climb small stairs and move on rough surfaces. The Raspberry Pi in the robotic vehicle is used to act as a controller and also as a server to allow web control. This report describes the design, construction and testing processes involved in the project in detail. Some important features of Multi-Utility Robotic Vehicle can be grouped as stair climbing, video capture, navigation, surveillance, etc. The robot can be used for navigating through different land terrains easily with help of live feed from the camera. The robotic vehicle can thus be used to monitor the behaviour and activities of the surroundings.**

I. INTRODUCTION

The Raspberry Pi is a low cost single board computer based ARM processor running the GNU/Linux operating system. It is powered by a Broadcom BCM2835 SoC that contains an ARM processor which runs at 700 MHz. The Raspberry Pi that we use is model B. The Raspberry Pi primarily uses Linux kernel-based operating system. Raspberry Pi is controlled by a modified version of Debian Linux optimized for the ARM architecture. The display contains a graphical user interface which provides various fields for data entry via an onscreen keyboard. Also, various fields were provided to display data obtained from a remote host.
Raspbian is a Debian-based free operating system optimized for the Raspberry Pi hardware.
In this implementation, the raspberry pi is used as the brain of the robotic vehicle. The camera as well as the motors are connected to the Raspberry pi through the USB and GPIO ports respectively. The Pi is connected to the internet with the help of a wifi adapter which again is connected to one of the USB ports.The Pi is connected to the internet and can be controlled through the web page hosted in Pi. The Pi is set up as a web server for this.

II. MAIN HARDWARE COMPONENTS

A. Raspberry Pi

The Raspberry Pi is manufactured in two board configurations through licensed manufacturing deals. The Raspberry Pi has a Broadcom BCM2835 system on a chip (SoC),which includes an ARM1176JZF-S 700 MHz processor. Some of its hardware features are:

- Memory - 512Mb RAM
- Connections - 2 USB ports, Ethernet port, 3.5mm jack for audio out, HDMI, Composite Video
- Videocore 4 GPU
- Capable of BluRay quality playback, using H.264 at 40MBits/s
- Has a fast 3D core accessed using the supplied OpenGL ES2.0 and OpenVG libraries
- Provides Open GL ES 2.0, hardware-accelerated OpenVG, and 1080p30 H.264 high-profile decode
- Capable of 1Gpixel/s, 1.5Gtexel/s or 24 GFLOPs of general purpose compute and features a bunch of texture filtering and DMA infrastructure
- Overall real world performance is something like a 300MHz Pentium 2.
- Power source - 5 V via MicroUSB or GPIO header

B. Motor

The Multi-utility robotic vehicle consist of four motors driven by two motor driver L293D IC. This driver IC is a quad, high-current, half-H driver designed to provide bidirectional drive. The L293D IC is 18 pin dual in line package which helps in driving the motor.

C. WebCam

The camera used is Logitech C270 model. Its relatively cheap for its specifications. Some of its features like video capture, photos up to 3.0 megapixels, hi-speed USB 2.0, etc

D. Accelerometer

Accelerometer measures acceleration in one to three linear axes (x, y, z). Unlike accelerometers have a fixed reference and only measure changes. The accuracy of the measured tilt angle is extremely important for balancing the robot on any adverse platform. In order to measure the tilt angle along a single axis, we need a gyroscope and an accelerometer.
The earths gravity is a constant acceleration where the force is always pointing down to the centre of the Earth. When the

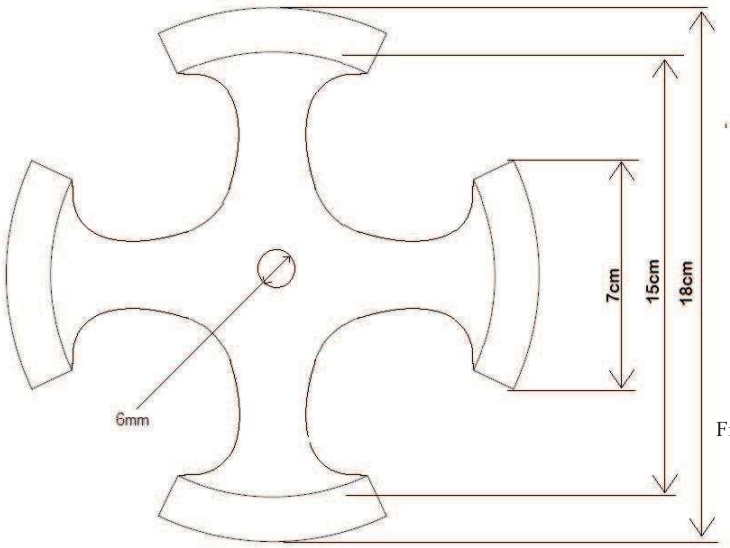

Fig. 1. Multi-utility robotic vehicle wheel model

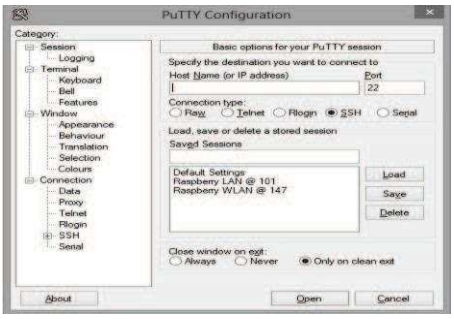

Fig. 2. PuTTY Configuration dialog box

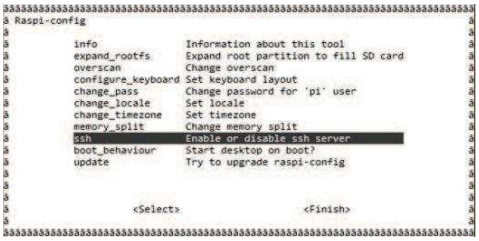

Fig. 3. Enabling SSH in the Settings dialog box of the Raspberry Pi

accelerometer is parallel with the gravity, the measured acceleration will be 1G, when the accelerometer is perpendicular with the gravity, it will measure 0G. In short, the tilt angle can be calculated from the measured acceleration by using this equation:

Angle = sin-1 (Measured Acceleration / Gravity Acceleration)

A single axis accelerometer can measure acceleration in whichever direction it is pointed. Knowing the acceleration and time, we can use mathematics to find the distance traveled by the object. There are fewer and fewer single and double axis accelerometers on the market because a triple axis accelerometer can do so much more.

For accurate measurements of tilt in the x and y planes we therefore need a 3 axis accelerometer. The angle is calculated using the formula .

x/y=tan(Angle)

III. Wheel Design

The wheel design chosen for the multi-utility vehicle is shown in Figure 1. This wheel design is chosen to allow easy movement on rugged terrain. The conventional wheel design usually have the disadvantage of restricted motion on rocky areas and stairs. The teeth at the ends and the groove cutting in the wheel helps to climb stairs easily by providing a pull from the front of the vehicle.

The wheel has an outer diameter of 18cm with each teeth 7cm wide. The inner hole in the wheel of diameter 6mm is used to attach to the motor axle. The teeth ends in the wheel have a curve shape inner joining which helps to avoid breakage and thus provides better mechanical stability to the wheel. This robotic vehicle uses four such wheels for its various applications.

IV. Working through SSH

Secure Shell (SSH) is an encrypted network protocol for secure data communication, remote command-line login, remote command execution, and other secure network services between two networked computers that connects, via a secure channel over an insecure network, a server and a client. It is a UNIX-based command interface and protocol for securely getting access to a remote computer. It is widely used by network administrators to control Web and other kinds of servers remotely. SSH is actually a suite of three utilities - slogin, ssh, and scp - that are secure versions of the earlier UNIX utilities, rlogin, rsh, and rcp. SSH commands are encrypted and secure in several ways. Both ends of the client/server connection are authenticated using a digital certificate, and passwords are protected by being encrypted.

In raspberry pi , there is a provision to turn on SSH. After this the pi is accessible through a ssh client running in a system in the same network as the raspberry pi. The SSH client used in windows is Putty. Another software we use to transfer files to and from the raspberry pi is winSCP.

V. Software Used

A. Python

Python is a popular programming language, with which the Raspberry Pi was built with in mind as being the core language to be used (actually thats where it gets the Pi part), although you can use other major languages such as C, C++ and Java. It is an extremely powerful and flexible language that will let you build virtually any software system you wish to, and you can even use it to control hardware on the Pi.

B. Apache

Apache is a freely available Web server that is distributed under an ”open source” license. Version 2.0 runs on most UNIX-based operating systems (such as Linux, Solaris, Digital UNIX, and AIX), on other UNIX/POSIX-derived systems

Fig. 4. Motion Control Web Page

(such as Rhapsody, BeOS, and BS2000/OSD), on AmigaOS, and on Windows 2000.

VI. Web Page

The web page is designed to have different tabs for control of its multiple utilities as shown. The main tabs are Motion control and Live video streaming.

A. Motion Control

In motion control, we get the page where we can control the motion of the robotic vehicle using up, down, left, right and stop arrows. These arrows are linked to the respective python code which will be executed upon clicking.

B. Live video streaming

The live video streaming is provided using a software called motion at port 8080 of Raspberry Pi. It can also be obtained using OpenCV and SimpleCV.

VII. Web Control

The Raspberry Pi is setup as a web server. The web server hosts the web page.The term web server can refer to either the hardware or the software that helps to deliver web content that can be accessed through the Internet. The most common use of web servers is to host websites, but there are other uses such as gaming, data storage or running enterprise applications.

For example, if we enter the URL http://www.pcwebopedia.com/index.html in the browser, this sends a request to the Web server whose domain name is-pcwebopedia.com. The server then fetches the page named index.html and sends it to the browser.

The online page of the project was done using HTML/CSS. HTML (the Hypertext Markup Language) and CSS (Cascading Style Sheets) are two of the core technologies for building Web pages. HTML provides the structure of the page, CSS the (visual and aural) layout, for a variety of devices. CSS is independent of HTML and can be used with any XML-based markup language. The separation of HTML from CSS makes it easier to maintain sites, share style sheets across pages, and tailor pages to different environments.

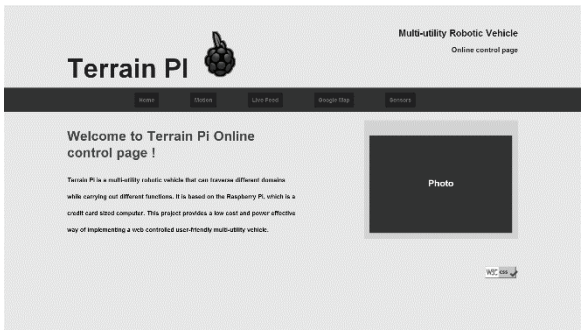

Fig. 5. Web page

Fig. 6. Video streaming page

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C. CGI-Common Gateway Interface

Most Web servers handle dynamic files - through a mechanism called the Common Gateway Interface, or CGI. Common Gateway Interface (CGI) is a standard method used to generate dynamic content on web pages and web applications. CGI scripts live in the servers special cgi-bin directory. The HTTP server places all sorts of information about the request in the scripts shell environment, executes the script, and sends the scripts output back to the client.

The scripts input is connected to the client too, and sometimes the form data is read this way; at other times the form data is passed via the query string part of the URL. The cgi module is intended to take care of the different cases and provide a simpler interface to the Python script. It also provides a number of utilities that help in debugging scripts

When implemented on a web server, provides an interface between the web server and programs that generate the web content. CGI comes preinstalled as part of APACHE. All the python codes are stored in the /usr/lib/cgi-bin folder. To run a python file via HTML it needs to be an executable file. We

make it executable using the chmod command in the raspberry pi shell. These programs can be accessed through hyperlink in the website.

VIII. Video streaming and Snapshots using Camera

It is very easy to create a live online feed of anything we want over the internet using Raspberry Pi and the web cam. Live video streaming can be done using different softwares and algorithms. The most commonly used one is the motion. Others include mpeg streamer, vlc, etc. It can also be done using SimpleCV with python. In this case, the code is very simple.To get live video feed from the camera, we can use the live() function. In addition to displaying live video feed, the live() function has two other very useful properties. The live feed makes it easy to find both the coordinates and the color of a pixel on the screen.

- To get the coordinates or color for a pixel, use the live() function directly.
- After the window showing the video feed appears, we can obtain the pixel of interest.
- The coordinates and color for the pixel at that location will then be displayed on the screen and also output to the shell. The coordinates will be in the (x, y) format, and the color will be displayed as an RGB triplet (R,G,B).

The software that we use to transmit the video stream is called Motion.

A. Using Motion

It is a streaming software that makes everything work with a built in web server.

- Easy to install and use.
- Automatic motion detection- A rectangle is drawn around the place where we detect motion.
- It can record continuously take snapshots.
- It can manually set configurations such as frame rate, size, quality, etc.

Using motion software, to view the streaming, we have to go to the IP address of Pi, i.e http://ip address:8081. The port allotted here is 8081 for streaming while it is 8080 for web configuration interface. As of now, this is available only in the local network.

B. Linking the video stream to the webpage

The video is linked to a webpage through the ¡iframe¿ frame in HTML. Iframe stands for inline frame. It represents a nested browsing context, effectively embedding another HTML page into the current page.

C. Snapshot using Python

Using SimpleCV in python, we can make use of the imgproc library to take snapshots.

IX. Conclusion

The multi-utility robotic vehicle was successfully implemented using R aspberry Pi. Here, the control of the motor for the robot's wheels was done by setting up the Raspberry Pi as a web server. The live video streaming and photos were also obtained from the vehicle.

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