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REMOTE CONTROL OF ROBOTIC ARM USING RASPBERRY PI

Ron Oommen Thomas[#1] and Prof. K. Rajasekaran[*2]

[#] *M.Tech, Department of Electronics and Instrumentation Engineering, Karunya University, Coimbatore, India*
[*] *Professor, Department of Electronics and Instrumentation Engineering, Karunya University, Coimbatore, India*

***Abstract*— Robotics is a rapidly growing widely innovated field. With the advances in technology, combining networking and robotics has a greate advantage in many aspects. Presently home automation is possible with smart devices by an internet control of home appliances. So using this for controlling a robotic arm remotely has greater advantages and applications.There are different ways to control these robots, but imagine the case of controlling a robot miles and miles away through the internet. This paper describes the use of internet to control the robotic arm from a remote end.**

***Index Terms*— Raspberry Pi, robotic arm, web server, internet.**

I. INTRODUCTION

With the popularity and widespread use of internet, it becomes an easy task for anyone to control the robotic arm from a remote end. Many spent more time in internet than the average time they sleep!! So by making the robotic arm to be controlled from internet, it becomes easy for anyone to use it from a remote end to use it for myriad of operations. With this, the industrialists can even do their work from home and can be used for various household chores, there by reducing the work force for may simple tasks.

The Raspberry Pi is developed in the UK by the Raspberry Pi Foundation and is a credit-card-sized single-board computer. Maplin‘s OWI-535 Robotic Arm (non USB type) is used. A web server can be created in the PC itself, by which the robotic arm can be controlled from a remote end [1], [2]. The robots can be controlled from internet and can be used for teleoperation [5], industry, automation, household applications [2]. By means of wireless technologies like Zigbee and RF, a robotic arm can be controlled [1], [4] but can‘t be controlled from a remote end, so by making an internet controlled robotic arm, it’s possible to control it from a remote end. A web server is set up on the single board computer named Raspberry Pi. Many web server applications are available for the Raspberry Pi and Lighhtpd web server application was chosen to be the server for Raspberry Pi [10]. With the Pi set as a web server, it’s possible for the client computers to access the data or web pages hosted by the Raspberry Pi server.

The GPIO pins enable Raspberry Pi to communicate with various hardware devices and there are 17 GPIO pins, with 9 being multifunctional. L293 motor driver boards are used for the Robotic Arm to be controlled from the GPIO pins. A web page is hosted in the server for the robotic arm control.

II. HARDWARE AND SOFTWARE

A. Raspberry Pi

The Raspberry Pi is available in two models- Model A and Model B. The Model A is cheaper compared to Model B but lack some conncetors. It was initially started with the intention of teaching the basic computer science in schools but later turned out to be a wonder in the field of single board computers.The Raspberry Pi has a Broadcom BCM2835 system on a chip (SoC), which includes an ARM1176JZF-S 700 MHz processor (The the user can attempt overclocking, up to 1 GHz, without affecting the warranty), VideoCore IV GPU, and was originally shipped with 256 megabytes of RAM, later upgraded to 512 MB. It does not include a built-in hard disk or solid-state drive, but uses an SD card for booting and long-term storage. The Broadcom BCM2835 incorporates an ARM1176 processor core. The ARM processors are low-cost yet high performance processors used in smart phones, digital TVs, eReaders and other media devices. ARM licenses the processor to other companies, like Broadcom, who combine it with various I/O modules and incorporate it into system-on-chip designs. ARM, also provides the physical IP for the digital inputs and outputs (GPIO) as cell libraries.

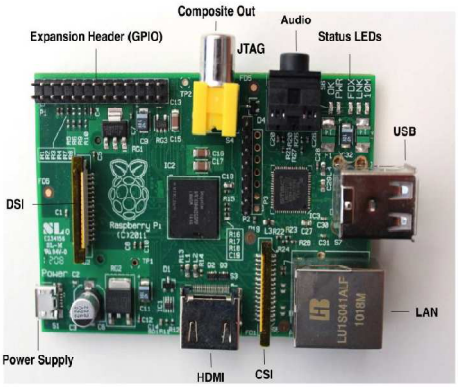

Figure 1: Raspberry Pi

B. *Robotic Arm*

The arm has four rotational joints, which is called the base, shoulder, elbow and wrist. The base rotates the arm around the vertical z-axis, while the other three rotate it around the x-axis. No joint rotates around the y-axis, which limits the arm movements, but also makes the kinematics calculations later in this chapter much easier. Each joint has a rotation limit in the backwards and forwards directions for the wrist, elbow and shoulder, and to the left and right for the base, which will become important later when rotations are implemented using angle values. The arm's gripper opens and closes via rotating gear wheels, but its prongs are connected to the wheels in such a way that they stay roughly parallel to each other as they move.

C. *Debian Distribution*

Debian is an operating system composed of free software mostly carrying the GNU General Public License. Debian was the default distribution on the Alpha boards. Boot time depends on width & speed of SD-card. Alpha board boot into Debian prompt (no GUI) was timed to take about 34 seconds. The Debian distro for Raspberry Pi is the Cambridge reference filesystem, which is a fully functional Debian Squeeze installation containing LXDE (desktop) and Midori (browser); development tools; and sample code for accessing the multimedia functionality on the device.

II. BLOCK DIAGRAM

The internet can be LAN or wifi. Here the Raspberry Pi is connected to the internet via LAN and the PC is connected to the internet via LAN or WIFI. Raspberry Pi needs an HDMI/VGA monitor for its display, which is here provided by the LCD projector via an HDMI interface. This is a two-way communication as the information is sent to the PC and the action from the web page will trigger the execution of python codes in the server as it retraces its path, thus the result can be viewed on the server side. The control signals to robotic arm is provided by the Pi and is the cause for it's movements. Standard RCA out can also be used as the display for Pi, instead of HDMI but lacks in clarity.

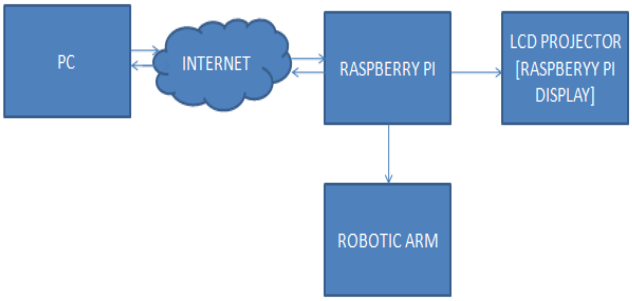

Figure 2: Block Diagram

III. WEB SERVER

Web servers refer to computers that can serve web pages. Every web server will have an IP address assignrd to it. When a user enters the URL in any web browser, a request is send to the web server having the same domain name. The server will fetch the corresponding file mentioned and sends it to the client browser.

A. *Raspberry Pi Web Server*

Even though the Pi is significantly less powerful than most devices one would find in a data center, that doesn't mean that it can't act as a useful server in a home or business environment. Despite a small amount of memory and relatively underpowered processor, the Pi's low power draw and silent running makes it a great choice for serving low-traffic simple pages to a local network or even out onto the Internet. A large proportion of modern web servers run a combination of Linux, Apache, MySQL and PHP—commonly referred to as a LAMP stack. Different web server applications are available for Raspberry Pi, like Lighttpd [10], Apache, Nginx, etc. It also has database support as a backend system for storing and retrieving data. Lighttpd having less footprint compared to Apache, is used as the web server in this setup. Lighttpd can be installed using the following command 'sudo apt-get –y install Lighttpd'. Similarly, PHP is also installed in the system using commands. Once everything is installed, the web server must be restarted to take effect. The default directory for storing the web server files is /var/www. So whatever files are placed in this directory can be served upon request from the client. The directory is currently owned by the root user, so permission must be given to the web server user to access the files in the directory. The web server user for Lighttpd is 'www-data'.

IV. IMPLEMENTATION

The Raspberry Pi doesn't have a hard disk or enough internal memory capacity, so we need to use an SD card for the data storage and for all other operations of Pi. First, an operating system has to be installed in Raspberry Pi. Linux based OS is the preferred for almost all single board computers and the scenario doesn't change with Raspberry Pi. Popular OS for Pi are Raspbian, Debian, Arch Linux, RISC OS, etc. The debian distribution based Raspbian is much preferred than any other. It's installed onto an SD card. A mouse and keyboard are required to work with it, and with the 2 USB ports available, it's possible to connect the mouse and keyboard to the system. Inorder to plug-in another USB device has to Pi, a powered USB hub must be used because the device will draw power from the Pi to work and this will cause Pi to hang. The external powered hub can provide the necessary power for Pi to operate, it will be good to use an external adapter of specidied rating. After the initial boot up, configurations have to be changed to suit our needs like initial boot up to the desktop, etc. The Pi is connected to a network and the IPV4-address assigned to the system need to be found using the command 'sudo ifconfig'. The address obtained will be the DHCP address, it's possible to change it to a static IP by editing the interface file present in /etc file. Then update the software and kernel as required to make the system up to date.

Figure 3: The Whole Setup

The web page can be designed using a suitable editor like nano or leafpad. The default directory for the web server is /var/www. It can be changed later in the Lighttpd configuration file. Python is the preferred language for Raspberry Pi, but it also supports Java, C, Ruby, etc. There are 5 motors for the robotic arm, so 3 motor driver ICs are required for the control of all the joints of the robotic arm. A triple L293 driver board (see Figure 4) is designed for the control of all the motors and is interfaced with the GPIO pins of Raspberry Pi. Python programs are written for the forward and backward motion of each joint of the arm and are linked with the PHP script.

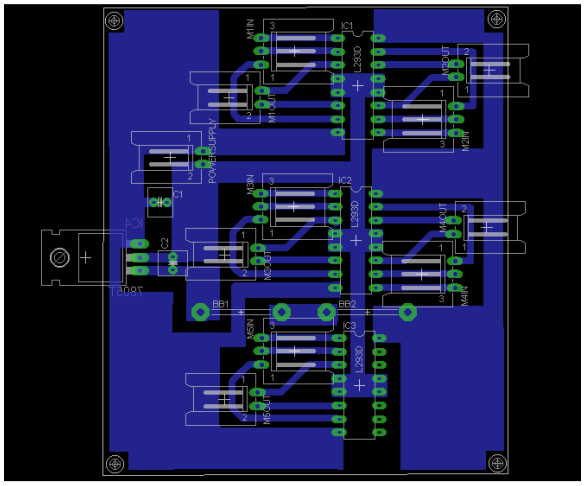

Figure 4 : Triple L293 Driver Board

V. RESULT

The web page designed for robotic arm control is shown in the figure 5. Buttons are created for the forward and backward motion of the 3 joints-shoulder, elbow and wrist, opening and closing of the gripper and the left and right motion of the base of the robotic arm. When the user clicks the button, the corresponding python code for the movement of each joint is executed in the server The address for the web page is 192.168.x.x/InternetRobo.php

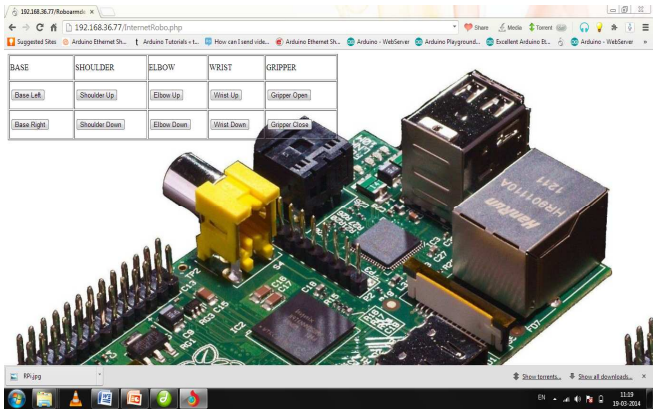

Figure 5: The Web Page for Internet Controlled Robotic Arm

VI. CONCLUSION AND FUTURE WORK

The Raspberry Pi can be used for the control of a Robotic Arm from a remote end. Imagine the case where the robotic arm can be controlled from anywhere in this world and for this, some visual feedback should be provided like a live video streaming of the robotic arm so an user can see the robotic arm from anywhere and control and at the same time, monitor the movements and actions of robotic arm through the web page. This data can be provided worldwide with port forwarding

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Ron Oommen Thomas received his B.Tech degree in Electronics and Communication Engineering from Mahatma Gandhi University, Kerala in 2011 and is pursuing the Masters degree specialized in Embedded Systems from Karunya University, Coimbatore. His areas of interest includes Robotics and Java.

Prof. K. Rajasekaran received his B.E degree in Electronics and Communication Engineering from PSG Tech, Coimbatore in 1976 and M.Tech from IIT Kharagpur in 1978 and is pursuing Ph.D from Anna University, Chennai. He is a specialist in the field of Instrumentation having behind him 25 years of industrial experience. Highlight of his industrial service is his tenure as R&D Engineer in Bharat Electronics Ltd., Bangalore. He has acquired extensive experience in military as well as space electronic equipments, both in design and manufacturing. He has 9 years of teaching experience. His area of specialization is in Embedded Systems.