TELEOPERATION OF ROBOTIC ARM
WITH VISUAL FEEDBACK

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ABSTRACT
A robot is a virtual or mechanical artificial agent which is guided by computer or electronic programming and is thus able to do tasks. Tele-robotics refers to control a robot from a remote end. Controlling robotic-arm wirelessly is very helpful for a wide range of applications ranging from industrial to medical fields. With the popularity and widespread use of internet, it becomes an easy task for anyone to control and monitor the robots from a remote end. In this project, a robotic arm is designed to be controlled by an authorized person at any time and from any place using the web technology. A web server is set up on the Raspberry Pi. From the client side, the control signals are sent over internet medium to a remote end raspberry pi to control the robotic arm. A USB camera is used for visual feedback to provide live video stream of the remote end to the client.

Keywords: Raspberry Pi, Robotic Arm, Web Server, Internet Control, Apache, Servo Motor.

I. INTRODUCTION

A robotic arm is a robot manipulator, which can perform similar functions to a human arm. Tele-robotics refers to control a robot from a remote end. Tele-operation applied to robotics vastly enriches the range of applications[1]. One can find examples in space, underwater, dangerous environments (power plants), hazards handling and medicine. Due to the intense development of the Internet, it can nowadays act as a medium connecting many locations (in different countries) using one single protocol. The availability of the Internet and its side tools also allows one to present recent technological developments in a popular and easy to us.

One way of controlling robotic arm wirelessly is by Zigbeetechology. But it cannot be controlled from a remote site[2]. Another method for the control of robotic arm is by Haptic technology which allows interactivity in real-time with virtual objects. Haptic devices are costly and have to be worn in hands. Many spent more time in internet than the average time they sleep. With the popularity and widespread use of internet, it becomes an easy task for anyone to control and monitor the robotic arm from internet.

The aim of this project is to develop a robotic arm which should be controlled by an authorized person at any time and from any place using the web technology[3]. 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 Apache web server application was chosen to be the server for Raspberry Pi. With the Pi set as a web server, it’s possible for the client to access the data or web pages hosted by the Raspberry Pi server.
II. HARDWARE AND SOFTWARE

2.1 Raspberry Pi

The Raspberry Pi is a credit card-sized single-board computer developed in the UK by the Raspberry Pi Foundation. The Raspberry Pi is based on the Broadcom BCM2835 system on a chip (SoC), which includes an ARM1176JZF-S 700 MHz processor, Video Core IV GPU and has 512 MB of RAM. The system has Secure Digital (SD) or MicroSD sockets for boot media and persistent storage.

![Raspberry Pi Board](image1)

**Fig. 1** Raspberry Pi Board

2.2 Web Camera

The visual feedback is provided by the HP-3100 web camera. It has a still resolution of 5.0MP, video resolution is of full HD and a smooth video is given by 5G wide angle lens. A USB hub is used to interface camera with Pi because it is difficult for Pi to power it up after an USB keyboard and mouse are plugged-in.

2.3 Robotic Arm

This robotic arm has ten servo motors, six to control the arm and four to control the gripper and equipped with a camera for visual feedback. It’s capable of lifting about 1kg. All joints run on ball bearings, including the gripper’s four segments. The robot uses two different power supplies, one for the electronics and the other (high amperage) for the servos.

![Robotic arm with webcam](image2)

**Fig. 2**: Robotic arm with webcam
2.4 PuTTY

PuTTY supports many variations on the secure remote terminal, and provides user control over the SSH encryption key and protocol version. In a Raspberry Pi, SSH is enabled in default. So it’s possible to connect to the Raspberry Pi remotely using the Login id and password.

2.5 Wi-Fi Module

EdimaxWi-Fi adapter is used with the raspberry pi to connect to a Wi-Fi network. It does not require any external power supply. The Wi-Fi is configured and the Raspberry pi can be accessed through the WLAN IP address.

2.6 Apache 2 Web Server

Apache supports a variety of features, many implemented as compiled modules which extend the core functionality. These can range from server-side programming language support to authentication schemes. Hypertext Transfer Protocol (HTTP) is the protocol that helps in the communication between client and server. Pages delivered are most frequently HTML documents which may include documents, images, style sheets and scripts in addition to text content. The Apache 2 is used to make the raspberry pi a web server.

2.7 Servoblaster

Servoblaster software for the Raspberry Pi provides an interface to drive multiple servos via the GPIO pins. The servo positions are controlled by sending commands to the driver saying what pulse width a particular servo output should use.

2.8 MJPG Streamer

MJPG-streamer takes JPGs from Linux-UVC compatible webcams, filesystem or other input plugins and streams them as M-JPEG via HTTP to web browsers, VLC and other software. It is used to get the visual feedback from the remote end.

III. BLOCK DIAGRAM

The Raspberry Pi is connected to the internet via WLAN and the client device is connected to the internet via LAN or WIFI. The USB webcam provides the visual feedback necessary for monitoring the robotic arm from a remote end. The robotic arm is controlled from the client side via the control signals passed over the internet medium.

Fig.3: Block diagram
IV. IMPLEMENTATION

4.1 Raspberry Pi Configuration

In order to use the Raspberry Pi, an Operating System (OS) is needed to be installed onto a SD card. Wheezy-Raspbian was installed as Raspbian OS. The internal memory of Raspberry Pi is 512MB, so an external storage memory is required for all the operations we do in the system, from storing data to installing an application. The Wi-Fi is setup so that the raspberry pi can be connected to the network. Once the Wi-Fi is available the Pi automatically connects to the network. SSh login with the WLAN IP address is done using Putty to connect to the Raspberry Pi.

4.2 Raspberry Pi As 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 LAMP stack, a combination of Linux, Apache, MySQL and PHP. Different web server applications are available for Raspberry Pi. Apache 2 web server is installed in the Pi and a default directory is defined. This directory is used to store the web server contents. The python scripts are stored in the directory. Once the Pi is made as a web server and connected to a network, the video streaming can be enabled by using the MJPG software and the configuration file has to be edited in order to suit our needs for live streaming. The default port is used to make and the video will be out is port 81. Servoblaster is configured to drive 10 servos and an active high pulse of 0.5ms to 2.5ms, where are given to controls the position of the servos. The pulse should be repeated approximately every 20ms, although pulse frequency is not critical. The pulse width is critical, as that translates directly to the servo position. By varying the pulse width the robotic arm can be controlled.

Fig4: Live stream with the HTML page
A CGI script is any program that runs on a web server. CGI defines a standard way in which information may be passed to and from the browser and server. Here the control signals are sent to Servoblaster. It controls the 10 servo motors and makes arm movement. Through the web interface, the start/stop of MJPG-streaming is done and even shut down of the Raspberry Pi is done.

The live stream is viewed in browser by entering the IP address with the port number ie.,192.168.137.100:8081. This stream can be accessed within a network. The sliders are used to move the arm. As the camera is attached with the arm, cam also tilts along with the arm. The grasp and release buttons in the page are used for grasping and releasing the objects. Video streaming is an integral part of this project as it serves as the means by which the user can monitor the robotic arm from a remote end, otherwise the client has no other way to determine whether the arm is moving or not, unless he is present at the local site where the arm is present.

V. CONCLUSION AND FUTURE WORK

In this project, the robotic arm is controlled by the client from a remote area with a visual feedback through internet medium. In future the interface can be made even better by using Hand Tracking and Recognition techniques to get the control signals for arm movement.

REFERENCE


