Robot Manipulator Control via Internet using a Embedded Mini-Web Server

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***Abstract*- This paper deals with the development of an embedded mini-web server for remote control of a robot manipulator via internet. This control system is based on typical TCP/IP and composed of two servers. One is the server for robot manipulator control and the other is the server that transmits images captured by CCD camera for monitoring the robot manipulator. This embedded mini-web server has minimum function for which a UNIX system or a PC is normally used. Most of the functions in each TCP/IP layer are realized by the software based on a microprocessor and a real time OS. For MMI (man-machine interface) a web-browser is used.**

I.INTRODUCTION

Network is changing not only the method of communication but also lifestyles of mankind. Recently, the needs that many kinds of work such as remote control and monitoring can be done using global network under any devices, networks and environments have been rising. Only a few years ago, highly expensive and complex systems were required for these needs. According to fast development of hardware and software technologies, embedded systems that have limited resource and can do a specific function have emerged have emerged [1,2].

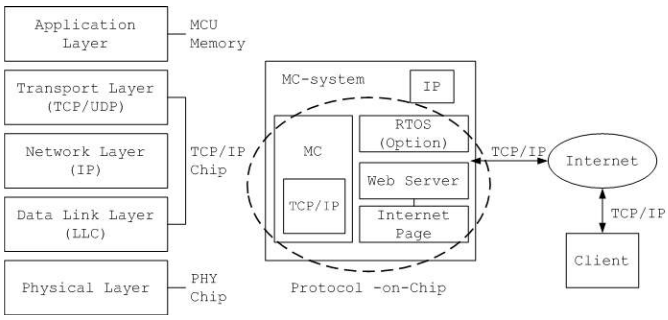
Embedded systems are commonly known as the control systems that software and hardware are compounded in for a specific demand. Among them, embedded web server is a subminiature web server which makes it possible that input-output device and intelligent systems are connected to the internet. Because of these advantages, embedded web server have been applying to various fields [3~5].

In this paper, embedded web server is made for remote control of robot manipulator. For embedded web server connecting to the network and transferring data via internet, exclusive device are needed which TCP/IP are embedded in. However, in this paper, 8bit microprocessor and real time operating system are used, and TCP/IP is implemented by software instead of exclusive device.

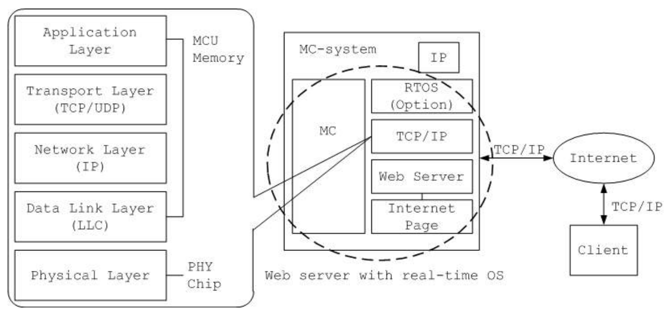
II.SYSTEM CONFIGURATION

A. Structure of embedded mini-web server

There are two types of embedded web server like Fig.1(a) [6]. One is the type using the device with a built-in TCP/IP like Fig.1(a). The other is the type that TCP/IP is embodied by software like Fig.1(b).



(a) TCP/IP protocol on chip



(b) TCP/IP software type

Fig.1. Types of embedded web server

In case of the type of Fig.1(a), many kinds of protocol such as TCP, UDP, IP and DHCP are built in a chip. Therefore, there are some advantages such as low cost and shortening of the time for development. However, there are some criterions such as the restriction of extension for another application and maintenance. In contrast to Fig.1(a), other layers except physical layer of TCP/IP are embodied to software in embedded web server of the type of Fig.1(b). In this case, it takes quite a long times for development. But there are advantages in respect of maintenance and extension of the applications. As a result, the time for development will get shorter and shorter. In this paper, type of Fig.1(b) is used.

B. Hardware configuration

8bit RISC processor, Atmega128 is used for main processor. Ethernet controller, RTL8019AS is used as buffer for TCP/IP frame data. Overall structure of embedded web serve is shown in Fig.2.

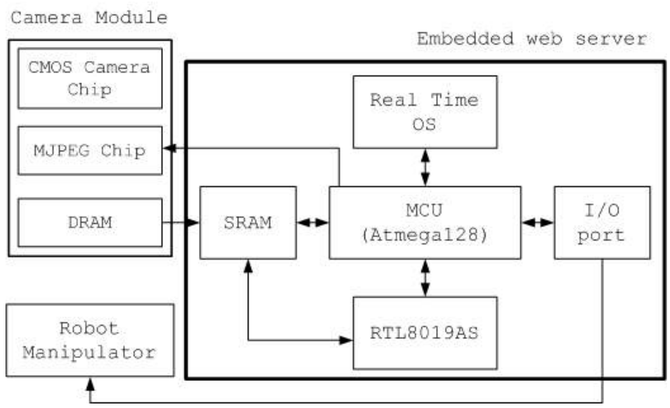


Fig.2. H/W block diagram of embedded web server

A gray image that is taken with camera module is converted to binary image and stacked within the internal data memory.

The external data memory is used for saving the TCP/IP frame data that is transferred from client via internet. MCU extracts the required data for control of robot manipulator from the frame data and transfer it to the robot.

C. Software configuration

There are two parts in the software for embedded web server. One is the real-time OS, which makes it possible to use the limited resource more efficiently. Fig.3 is the components of real-time OS. In our system, Nut OS is used for this. The other is TCP/IP stack like Fig.4.

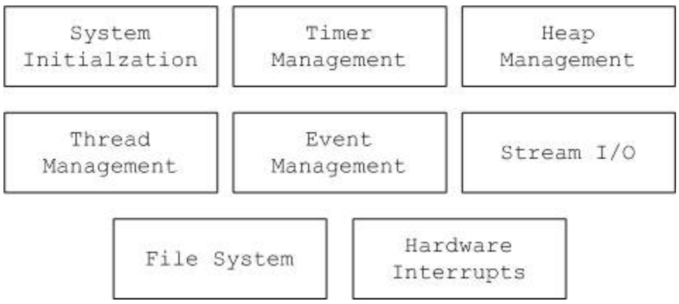


Fig.3. Real time OS block diagram

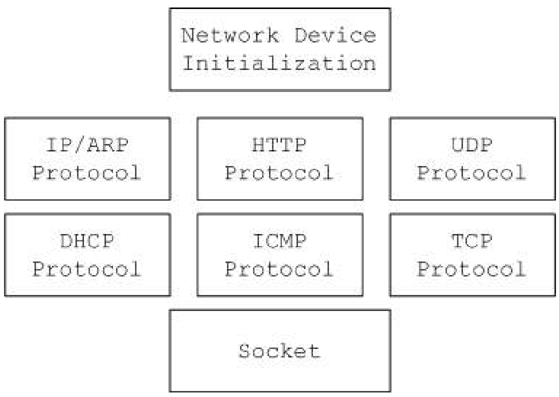


Fig.4. Ethernet protocols

Generally, PC or UNIX system use CGI (common gateway interface) for providing various web contents. But it is difficult to give these functions to embedded web server because of limited resources. Also, there are some problems in reentrance and multitasking when many applications are operate at the same time. Therefore, in our system, EGI (embedded gateway interface) like Fig.5 is implemented instead of CGI.

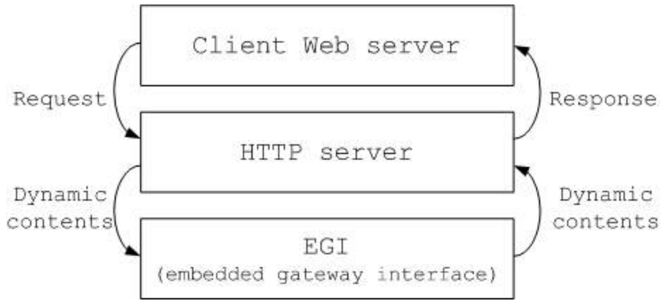


Fig.5. EGI (embedded Gateway Interface)

III.EXPERIMENTS

Fig.6 is the embedded web server that is composed. Fig.7 is the authentication pate, which is necessary because connection to embedded web server by unspecified number of the general publics in network is possible, and malfunction of target system or high traffic problem may be happened by it. Using this server, some experiment was done.

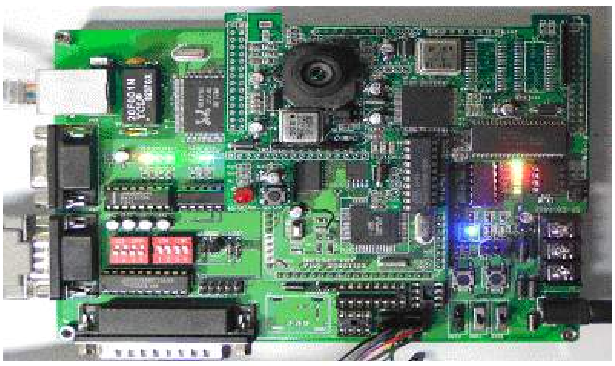


Fig.6. Embedded web server

Fig.7. Authentication page

A. Remote input-output control

Fig.8 is input-output control experiment. This control page is transferred from web server to an authentic client. If the client checks and commands, the control data is transferred via internet and embedded web server control I/O port. Also each port status is transferred to the client periodically.

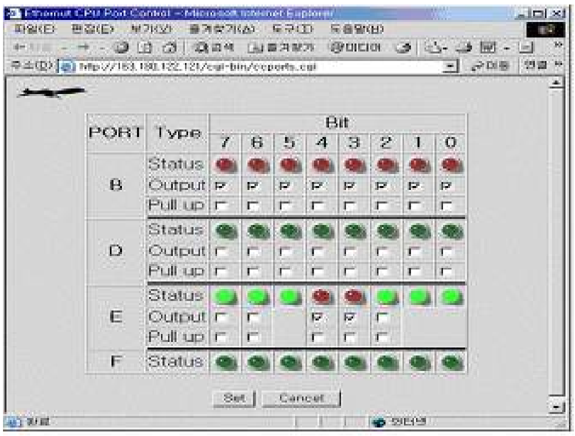


Fig.8. Input-output port control

B. Remote control of robot manipulator

Kinematics model of robot manipulator is like Fig.9. The position of end-effectors is defined by forward kinematics and each joint angle is calculated by inverse kinematics [7].

Fig.10 shows the experiment through web browser, and Fig.11 shows that the experiment through GUI (graphic user interface).

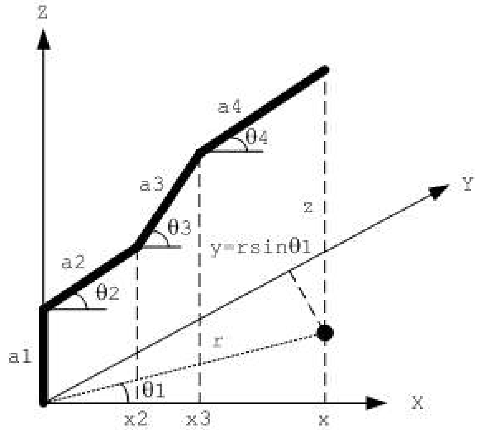


Fig.9. kinematics modeling of 4-D.O.F robot manipulator

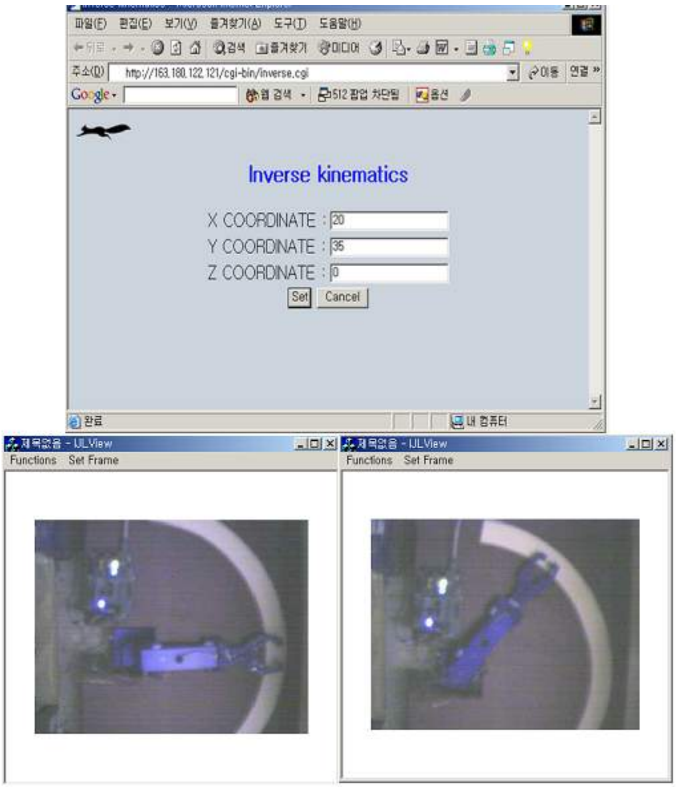


Fig.10. Control of robot manipulator via web browser

In Fig.10, a client inputs the position of end-effecter and commands. Then, embedded web server receives the position data and calculates each joint angle using inverse kinematics and drives each joint. And motions of robot manipulator are transmitted to the client via internet. Transmission of control data and monitoring images is carried out through web browser. Control data is transferred using TCP and monitoring image is transferred using UDP (user datagram protocol).

Fig.11 is the pick and place experiment through GUI. The position of the target object is calculated through simple image processing about transmitted image. Then, each joint angle for end-effecter to reach the target object is calculated by inverse kinematics. The remaining processes are same as the processes in Fig.10.

Fig.11. Pick and place experiment through GUI

IV.CONCLUSION

This paper deals with the development of an embedded mini-web server for remote control of a robot manipulator via internet.

This control system is composed of two servers. One is the server for robot manipulator control and the other is the server that transmits images captured by camera module for monitoring the robot manipulator. This embedded mini-web server has minimum function for which a UNIX system or a PC is normally used.

Most of the functions in each TCP/IP layer were realized by the software based on a microprocessor and a real-time OS. For MMI (man-machine interface) a web browser is used.

A user in a client site commands a target position on the web-browser screen. Each joint angle of the robot manipulator is calculated by inverse kinematics, and this data is transmitted to the embedded mini- web server via internet.

A camera image was used for monitoring the workspace and the recognition of obstacles and current position.

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