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Procedia Engineering 41 (2012) 1065 – 1071

Engineering Procedia

www.elsevier.com/locate/procedia

International Symposium on Robotics and Intelligent Sensors 2012 (IRIS 2012)

Internet Controlled Robotic Arm

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Abstract

When we talk about robots, people tend to think that robots are only suitable to use in the industry or just for the scientist to test about new technologies. However, the main function of robots are to help humans in doing work either in the industries or just helping out doing normal household chores. To bridge the gap of the normal perception of "robots are for the industries only", internet will be use. This paper presents the development of an internet controlled robotic arm. The movement of the robot arm can be controlled by a computer via the internet. This robot can be used to demonstrate that a robot can be used inside a home for daily human chores. The robot is controlled by Arduino Uno that interfaced with the internet using Arduino Ethernet Shield. Two type of analysis were done for this project that is servo motor analysis and accuracy test. The accuracy test shows that the results of the actual output of the servo motor as compared to the input send to Arduino Uno via internet is between 97% to 99%. This prototype of the robot showed that the operational was successful. This user friendly robot is expected to bridge the gap between robot and household chores.

Keywords: Robotic arm, internet controlled robot, Arduino Uno, Arduino Ethernet

1. Introduction

Robots are increasingly being integrated into working tasks to replace humans especially to perform the repetitive task. In general, robotics can be divided into two areas, industrial and service robotics. International Federation of Robotics (IFR) defines a service robot as a robot which operates semi- or fully autonomously to perform services useful to the well-being of humans and equipment, excluding manufacturing operations [1].

On the other hand, internet nowadays is becoming the center for everything. People tend to get online rather than doing household chores. Internet is now everywhere, compare to the last decades where internet is only wired, and people needs to be in front of the computer to access the internet but nowadays, internet is just at the tip of your finger. This is an advantage to introduce robot to household.

The robot body was prepared mechanically and electrical components were chosen to be suitable to be used as a robotic arm. The robot is controlled using Arduino Uno as the brain of the robot, connected to the internet via Arduino Ethernet Shield as the interface for Arduino Uno to the internet. Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. The movement of the robot is controlled by inputting the desired degree of movement of the robotic arm and then the robotic arm will move to the desired movement that has been inputted. There is also a pre-programmed movement of the robotic arm with a click of a button.

In this project, webserver developed using HTML is used to make the user interfaced that will be displayed when the operator access the robotic arm via the internet to control it.

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1877-7058 © 2012 Published by Elsevier Ltd.
doi:10.1016/j.proeng.2012.07.284

2. Literature review

In the past, there are some researchers that used internet to control their robot, reference [7] suggest to use SOAP protocol and used a PC server with ASP.NET framework and also a PC client that have been develop with ASP.NET framework. The suggested protocol takes about 30 seconds to respond due to the overhead in the Web service, since the Web service works as request-response base, it spoils the computation efficiency in the simulator.

Meanwhile references [8] suggest using an industrial standard PC architecture running LINUX, and a network interface which supports a wireless TCP/IP Ethernet link. The robot is the NOMAD-200 that has a server workstation that runs on UNIX, and an industrial standard PC that runs on LINUX. Because of the similarity of the operation systems of the server and robot, the communication between the two computers can be implemented by applying UNIX socket. Two transmission ports are used to create two virtual channels in their system.

This paper presents a simple internet based controlled robotic arm using Arduino Uno embedded system as the core of this robot and also Arduino Ethernet Shield to interface the robot with the internet. The robot does not require training because the robotic arm is fully controlled by the user.

3. Methodology

The robot has been design to mimic the movement of a human arm. This section will present a full description of the hardware of the robot design and it is divided into two main sections: mechanical and electrical design.

3.1. Project overview

In this project, the hardware and software function are combined to make the system reliable. Arduino Uno is the brain of this project and Arduino Ethernet Shield interfaced Arduino Uno with the internet. The project overview is as shown in Fig 1.

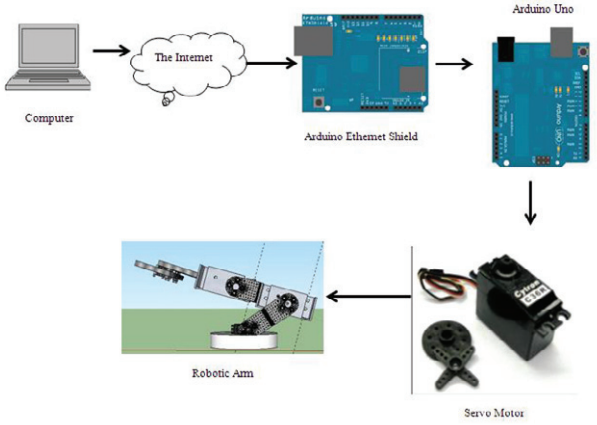


Fig 1: Project overview of internet controlled robotic arm.

3.2. Mechanical design

The robot had a round base with a diameter of 22cm and the height of 15cm. The robot degree-of-freedom mechanism is directly powered by servo motors. Acrylic is used as the robot base because it is easy to be formed, cheap, strong and can bear the motor weight and movement. The robotic arm is constructed using servo brackets that are made of aluminums because it is lightweight but stiff to mimic the bone structure of a human arm. The robot gripper is also made of aluminum because of the same reason as the main robot arm structure.

3.3. Electrical design

The block diagram shown in Fig 2 presents the main structure of the robotic arm. Basically, this robot has 5 outputs which consist of the robot base, the robot shoulder, the robot elbow, the robot wrist, and the robot gripper. Fig 3 shows the specific block diagram of the robotic arm.

Primary source of power for the robot is a 12V/1.2Ah Lead Acid battery because of its characteristics and advantages. The main source then is regulated to 5 volts using voltage regulator LM78XX. Servo motor is one of the DC type motors with feedback that used in many applications that required controlling the system in up-down direction. Servos are extremely useful in robotics [2]. Servo motor provides low RPM with high torque. Since the high torque is essential for this project. Therefore servo motor 180 is preferred in this project.

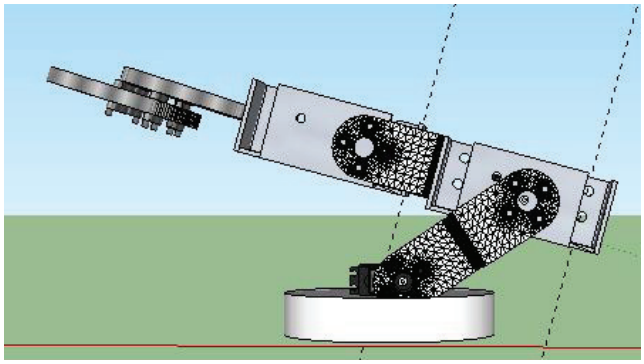


Fig 2: Side view of the internet controlled robotic arm

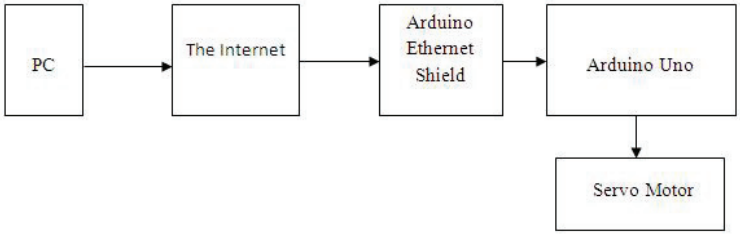


Fig 3: Specific block diagram of internet controlled robotic arm

3.4. Robot control system

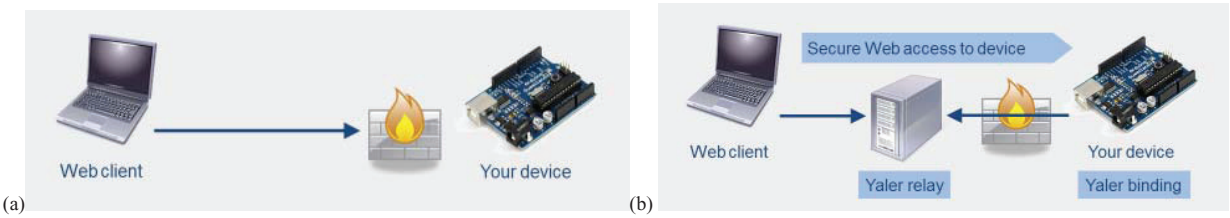
This system has two main parts which are the robotic arm and computer system. In this project, the Arduino Uno is the controller of the entire system. Arduino Uno will interface to the internet via an Arduino Ethernet shield, Arduino Ethernet shield will enable the Arduino Uno to interconnect to the internet via LAN cable. Then, any computer that has internet connection can access and control the robotic arm.

To enable the robotic arm for connection via the internet, relay infrastructure is used. Relay infrastructure enable secure Web access to embedded systems behind a firewall or NAT. One company gives a free-to-use relay infrastructure that is yaler.net. Fig 4(a) and Fig 4(b) shows the illustration on how a typical internet works and how to bypass firewall or NAT by using relay infrastructure. [6]

Fig 5 shows the flowchart of the internet controlled robotic arm. The operation of the robot starts with checking the servo motor and rotates to its initial position. When the servo motor is in its initial position, the controller will awaits for new command. The controller is embedded with a webserver written in HTML, when a computer access the controller, the computer will display a simple GUI that has been programmed inside the controller.

3.5. System architecture

Table 1 shows the project specification for this internet controlled robotic arm. The main purpose of producing this specification is to clarify some important aspects of the project and to make sure that the project is feasible as well as appropriate to use in the market.



(a) (b)

Fig 4: (a) Common internet connection problems to the embedded system and (b) how to solve it.

Table 1: Specification of Internet Controlled Robotic Arm.

Module	Specification
Supply from battery	12 Volts DC
Power Consumption	Volts DC
Controller	Arduino Uno
Internet connector	Arduino Ethernet Shield
Programming language	Arduino language
Actuator	Servo motor

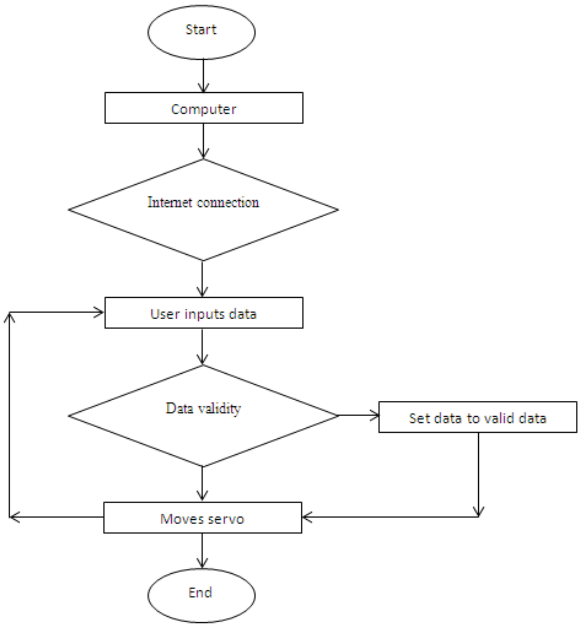


Fig 5: Flowchart of internet controlled robotic arm.

3.6. Software robot design

The robot software complements the hardware architecture of the inspection robot by providing basic low-level hardware control that includes reading the input value from the internet and controlling the servo motors.

Arduino Uno is a microcontroller board based on the ATmega328 [3]. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller.

Arduino IDE: Arduino hardware is programmed using a Wiring-based language (syntax and libraries), similar to C++ with some slight simplifications and modifications, and a Processing-based integrated development environment. Arduino is programmed using Arduino IDE that has been develop using Java and based on Processing, avr-gcc, and other open source software [4].

HTML-Kit: HTML-Kit is a powerful program to create web server using HTML coding. HTML-Kit is a proprietary HTML editor for Microsoft Windows made by chami.com. The application is a full-featured HTML editor designed to edit, format, validate, preview and publish web pages in HTML, XHTML and XML -languages. HTML-Kit colors HTML code and has built-in preview [5].

4. Result and discussion

Fig 6(a) shows a photo of the completed internet controlled robotic arm. Fig 6(b) shows the GUI that was developed using HTML codes. If the GUIs were not used, people would have to work from the command line interface, which can be extremely difficult and frustrating.

The control panel of the GUI for this project consists of two sections:

- "Manual Setting" for manual control of the robotic arm;
- "Automatic Function" for pre-programmed robotic arm movements.

The Internet Controlled Robotic Arm as shown in Fig 7 has been develop and will be applied in real world application. It can mimic the movement of a human arm such as pick and place and manoeuvre around.

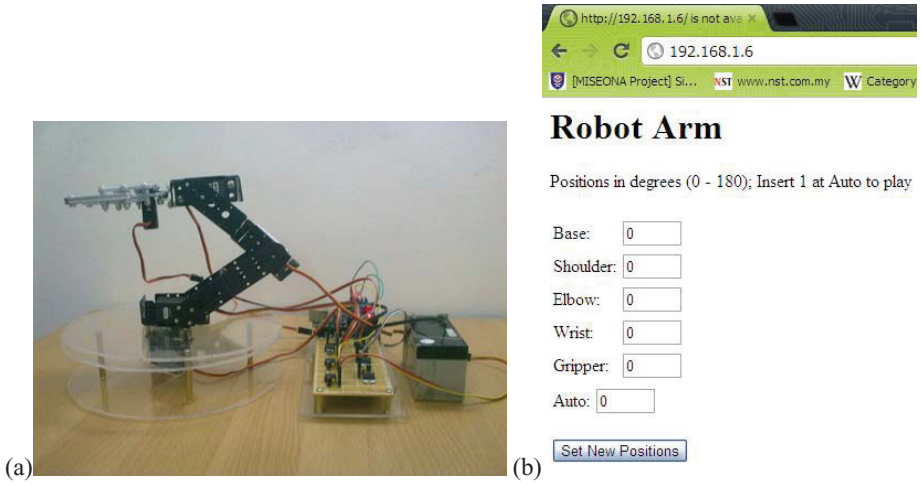


Fig 6: (a) Completed internet controlled robotic arm and (b) Completed GUI for internet controlled robotic arm.

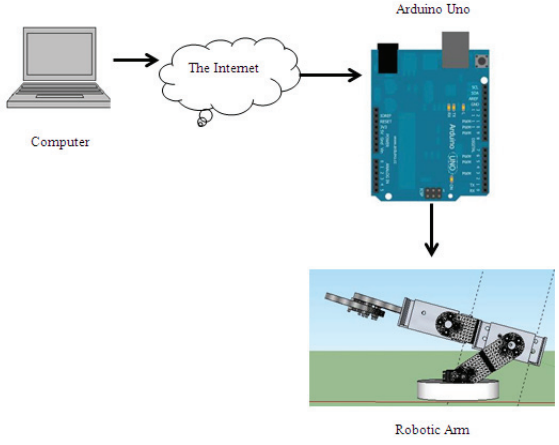


Fig 7: The internet controlled robotic arm.

4.1. Servo motor analysis

A servo motor has three wire output. Two of them are for power and ground and another one is lead feeds a position control signal to the motor. Servo motor is controlled by a series of pulses, wherein the length of the pulse indicates the position to take. Fig 8(a), Fig 8(b) and Fig 8(c) shows the pulse and the rotation of counter clockwise, in neutral position and clockwise rotation respectfully.

Table 2 shows the servo motor pulse width and location. Increasing the pulse width by 10μSec will results about one degree of movement on the output shaft. These numbers are nominal, and vary slightly between manufacturers and models.

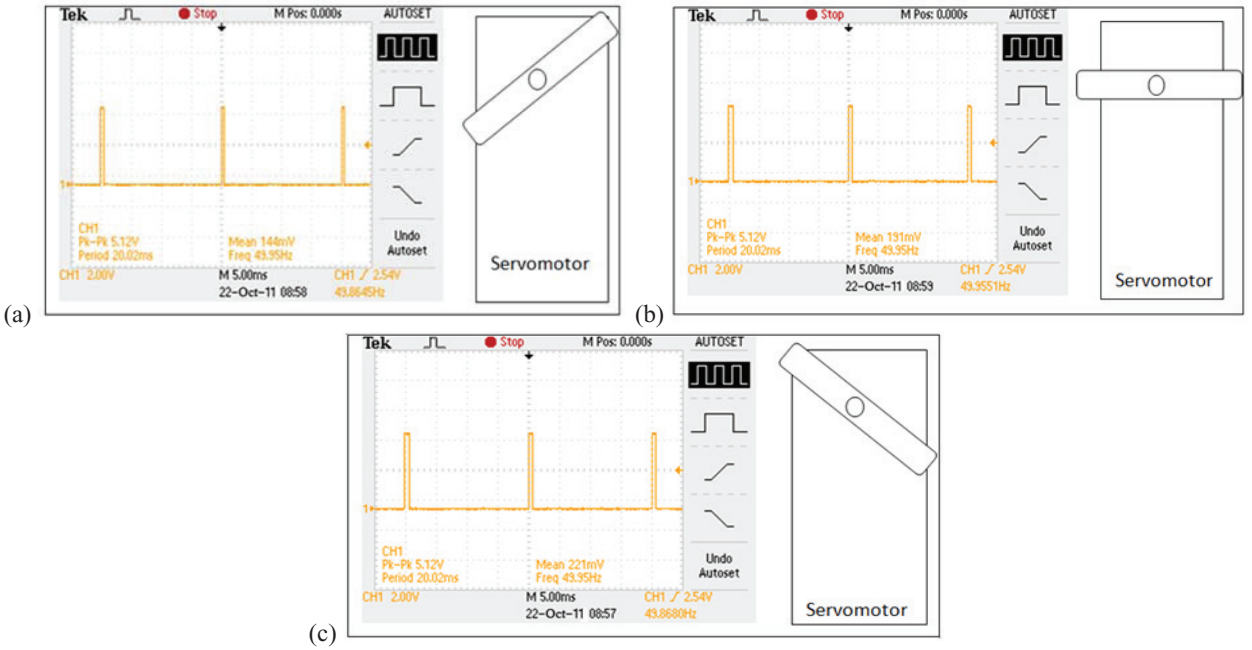


Fig 8: (a) Servo motor rotating counter clockwise and its pulse, (b) Servo motor rotating at neutral position and its pulse and (c) Servo motor rotating at clockwise position and its pulse.

Table 2: Servo motor pulse width and location

Pulse width	Angle	Comment
0.6 mS	-45 degree	Minimum pulse length
1.5 mS	0 degree	Centre position
2.4 mS	45 degree	Maximum pulse length

4.2. Accuracy test

Accuracy test is done to check how accurate the servo motors are when a new position value is send to Arduino Uno via the internet from a computer. Three value was transmitted, 45°, for the minimum position, 90°, for neutral position, and 180°, for maximum position. Table 3 shows the output accuracy of the servo motor in percentage.

Table 3: Servo motor accuracy

Location.	Output accuracy (%)		
	Minimum	Neutral	Maximum
Base	98	97	97
Shoulder	98	98	98
Elbow	97	98	98
Wrist	98	98	99

5. Conclusion

Overall, this project can be divided into two major sections that are hardware development and software development. The hardware operations include the automation process of controlling servo motors and also develop the robotic arm link and joint. Software development consists of developing the web server and also programming the Arduino Uno.

From the analyses that have been made, it's clearly shows that controlling a servo motor is quiet easy and the output is accurate. Thus, it is the right choice to choose servo motor for the actuator of the robot arm.

The purpose of this project is to show that robots not only restricted to industrial usage only but also suitable for household usage. Taking advantage of the widespread usage of internet connectivity nowadays, robots can be controlled via internet instead of a dedicated controller just for the robots. The main features of this robot is quite the same as [8]. This project was successful and proved that robots can be controlled via internet and it is suitable for household usage.

6. Recommendation

Generally the robot program runs smoothly with the base, shoulder, elbow, wrist and gripper move and rotates as planned. But, there still some improvement that could be made such as adding a camera to the robot for the user to see the movement of the robot via the internet, and redesign the robot arm to suit a specific task for household usage.

Acknowledgements

The authors would like to thank Engr. Reza Ezuan bin Samin for the support and guide, for criticizing and commenting the project until success. The authors also would like to thank Thomas Amberg for the tutorial on Arduino web service programming.

References

[1] R. C. Luo , K. L. Su,.A multi agent multi sensor based real-time sensory control system for intelligent security robot. IEEE International Conference on Robotics and Automation, vol. 2, 2003, pp.2394 .2399.
[2] Riazollah Firoozian, "Servo Motors and Industrial Control Theory." Springer; 1st edition (December 8, 2008).
[3] Massimo Banzi. "Getting Started with Arduino", O'Reilly Media, Inc, 1st Edition, pp. 21 – 22, 2011.
[4] Arduino entry, http://en.wikipedia.org/wiki/Arduino accessed on 10th December 2011 at 10.30 a.m.
[5] HTML-Kit entry, http://en.wikipedia.org/wiki/HTML-Kit accessed on 2nd February 2012 at 11.30 p.m..
[6] Yaler entry, https://yaler.net/ accessed on 2nd Febuary 2012 at 11.40 p.m.
[7] Keitaro Naruse and Makoto Oya, "Muscle-like Control of Entertainment Robot over Internet", International Conference on Advanced Intelligent Mechatronics, Monterey, California, USA, 24-28 July, 2005.
[8] Tse Min Chen and Ren C. Luo," Multisensor Based Autonomous Mobile Robot Through Internet Control", Department of Electrical Engineering, National Chung Cheng University.