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Build and Interface Internet Mobile Robot using Raspberry Pi and Arduino

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Abstract
In the recent years, the increasing use of wireless applications and the demand for a system that could easily connect devices for transfer of data over a long distance without cables became worldwide. This paper presents the Build and interface of a real time wheeled mobile robot installed above it an arm and a camera. Software system can be built in three various programming languages and controlled via the internet using webpage protected with a username and password to make sure it cannot be hacked. The webpage is designed to control the mobile robot remotely through the internet by any web browser such as Mozilla Firefox. Camera is mounted on the animated base in two axes in order to have better visibility.The designed mobile robot can be remotely operated from everywhere around the world without being near the robot. It can be controlled by using any device, whether a laptop, a mobile or a tablet. It can move forward, reverse, turn right and left for a specific distance according to the controller specification. The mobile robot system is used to transfer foreign objects and access to areas that are unable to be accessed by humans. It is also used for purposes of monitoring to fit a camera. The development of this robot is based on Arduino Mega platform which will be interfaced with the microcomputer that is placed on the robot running as a server. After completing the design and testing the robot, time delay is calculated in different cases (LAN and WAN) network. Finally, this prototype of the robot is expected to solve many problems such as placing or picking objects that are far away from the user, picking and placing hazardous objects in the fastest and easiest way.
Keywords: Internet Mobile Robot;Raspberry Pi ; Arduino.

1. Introduction

The term robot comes from robota which is a Czech word meaning forced labor. For Swedish roboticists, the word robot in Swedish is also used for military missiles. Automated software programs that crawl the Internet are also called robots [1]. Mobile robots are generally those robots which can move from place to place across the ground. Mobility gives robot a much greater flexibility to perform new, complex, exciting tasks. The world does not have to be modified to bring all needed items within reach of the robot. The robots can move where needed. Fewer robots can be used. Robots with mobility can perform more natural tasks in which the environment is not designed especially for them. These robots can work in a human-centered space and cooperate with men by sharing a workspace together [2]. Nowadays, robots are increasingly being integrated into working tasks to replace humans especially to perform repetitive tasks. The mobile robots are currently used in many fields of applications including office, military tasks, hospital operations, dangerous environment and agriculture. Besides, it might be difficult to the worker who must pick and place something that can affect badly[3],such as Welding is considered as a dangerous task for a humans because of toxic gases emissions, Painting has similar problems to welding due to the use of toxic chemical products, assembly operation: When we assemble a chip we need to be very precise because of very fine wires which require very precise and accurate tasks which a human cannot handle but, on the other hand, is easy for a robot and space missions to gather samples from other planets and to analyze them from remote distances[4]. Therefore a locomotion robot can replace human to do work. The robot is wireless controlled to ensure it can be used a long way from the user [3].

This paper describes the build a real time mobile robot system based on using internet communication. This project shows how to implement mobile robot system by interface the microcontroller (Arduino) with microcomputer (Raspberry Pi) by using serial port. The microcontroller is programmed in arduino C language and the microcomputer is programmed in python language, the mobile robot system contain camera moving in two axes and 5-DOF arm robot to hold objects. The mobile robot can be controlled by web page programmed in java script language. Necessary programs are installed to run server and camera correctly, then the system is connected wirelessly via internet and time delay is calculated in different cases (LAN and WAN) network.Mobile robots are generally those robots which can move from place to place across the ground. Mobility give a robot a much greater flexibility to perform new, complex, exciting tasks. The world does not have to be modified to bring all needed items within reach of the robot. The robots can move where needed. Fewer robots can be used. Robots

with mobility can perform more natural tasks in which the environment is not designed especially for them. These robots can work in a human-centered space and cooperate with men by sharing a workspace together [2].

Wei, Pan, & Furuta, 2005 [5], presented an Internet-based tele-control system for a wheeled mobile robot. A real-time embedded controller using Labview was designed to control the mobile robot remotely through the Internet by a Web browser, for example, Internet Explorer or Netscape. A CCD camera is mounted on the mobile robot to acquire information, which is displayed inside the browser for the remote operator's operation. The designed mobile robot can be remotely operated from anywhere around the world as long as there is a set of computers with keyboard, mouse, display and connection to the Internet. Zhang, 2012[6],This project is a robotic vehicle that can be controlled remotely by Skype text messages. A wireless webcam is mounted on the robot, and a live video/audio stream is relayed back to the remote operator via Skype video chat. The robot is wirelessly connected to its host PC with two Xbee modules. The remote operator PC and the local host computer are connected by two Skype clients via the Internet. More sensors and servos can be added to the robot, and controlled remotely by Skype text messages

2. Methodology

2.1 Project overview

In this project, the hardware and software function are combined to make the system reliable. The Raspberry pi and Arduino Mega will be the interfacing for the mobile robot and can be controlled wirelessly through the Internet by using webpage.The project overview is shown in Fig(1).

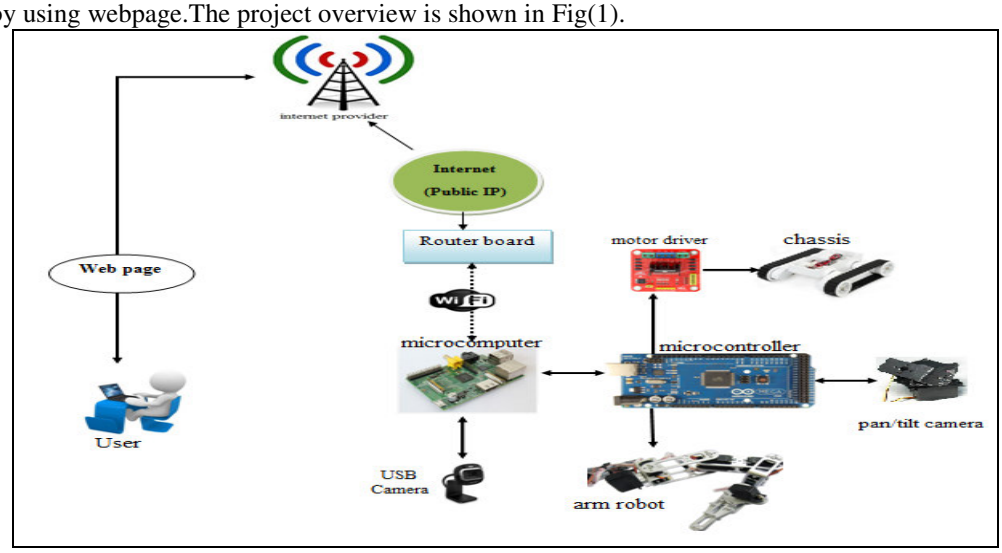

Fig.(1)Overall system design

2.2. System structure

The project specification for this wireless mobile robotic arm is shown in table (1). The main objective of Production this specifications is to illustrate some significant aspects of the project to ensure that the project is feasible also suitable for use in the market.

Table 1 Specification of internet Mobile Robot Arm

Module	**Specification**
Microcomputer	Raspberry Pi
Microcontroller	Arduino Mega
Programming language	Arduino language + Python +Java script
Actuator	Servo motor + DC motor
Robot Arm	5DOF arm with gripper
Motor driver	L298N

2.3. Software development

Software is a set of programs, procedures, algorithms and its documentation concerned with the operation of a data processing system. In this case, software is needed in order to complete task for the project.

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 developing using Java and other open source software.

Raspbian operating system: we need to install Raspbian on Raspberry Pi.

WebIOPi: is a web application which allows you to control your Raspberry Pi. Just install it on your Pi, and use any browser from your network.

Motion Program: motion program is going to be set up so the garage door's status can be checked up using a webcam.

Putty program:A special program to control of Raspberry Pi Wirelessly

2.4. Software Algorithm

The theoretical work in this paper is represented by many programs. Java script program, Python program, Arduino program and motion program for camera. These programs must work as one unit for the success of the work, as shown in Fig.(2) illustrates the flow chart of software algorithm.

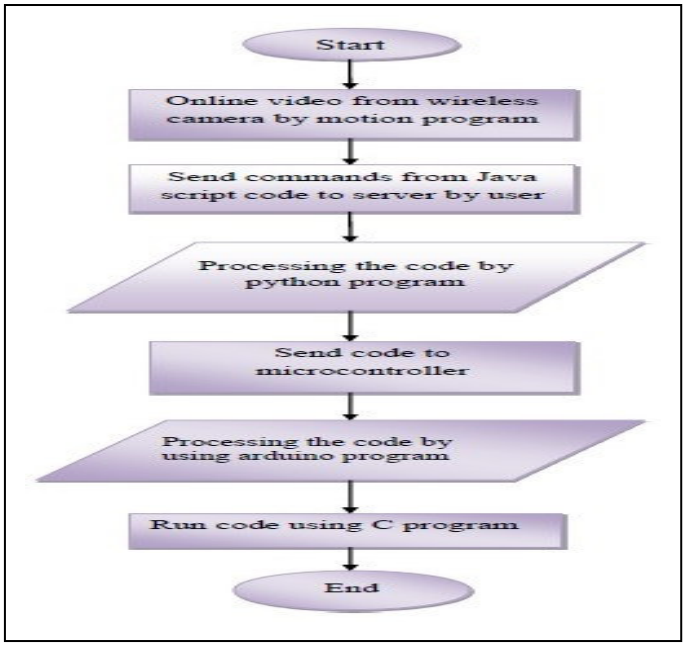

Fig. (2) Flow chart of software algorithm

3. Microcomputer/Raspberry Pi

To connect the mobile robot to the Internet and the installation of the various programs, we need a certain computer specifications, in this project we used microcomputer called 'Raspberry Pi' because of its good specifications and possibilities and high flexibility in dealing with different programs. Fig.(11) shows the Raspberry Pi model B.

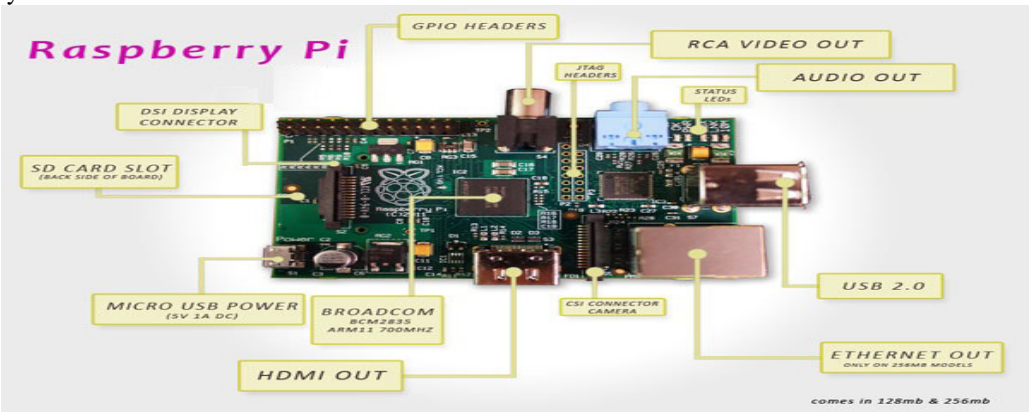

Fig. (11) Raspberry Pi Model B

4. Pan/tilt turret

To allow control of the camera position without moving the robot frame, a pan-and-tilt base for the camera is needed as shown in Fig.(12). The pan-and-tilt functions are achieved using two standard sized hobby servo motors to create X and Y axes with 180-degrees rotation along either axis. This setup gives a full view of

anything in front of the robot and enables much more precise movement than is provided by the robot base and the ability to look up and down [7].

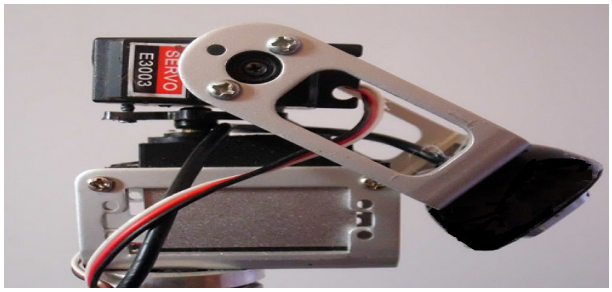

Fig. (12) two standard servos mounted on top of each other for pan/tilt motion

5. Electrical design

5.1 Arm Robot interface.

The six servos arm robot is controlled in the same way of the pan/tilt.A PWM signal of microcontroller (Arduino mega) with a pulse width of the servo motors of the arm robot. An increase or decrease of the pulse width will increase or decrease the servo angle respectively up to a maximum of about ±90° from center position, to as shown in Fig.(3) and Fig. (4)

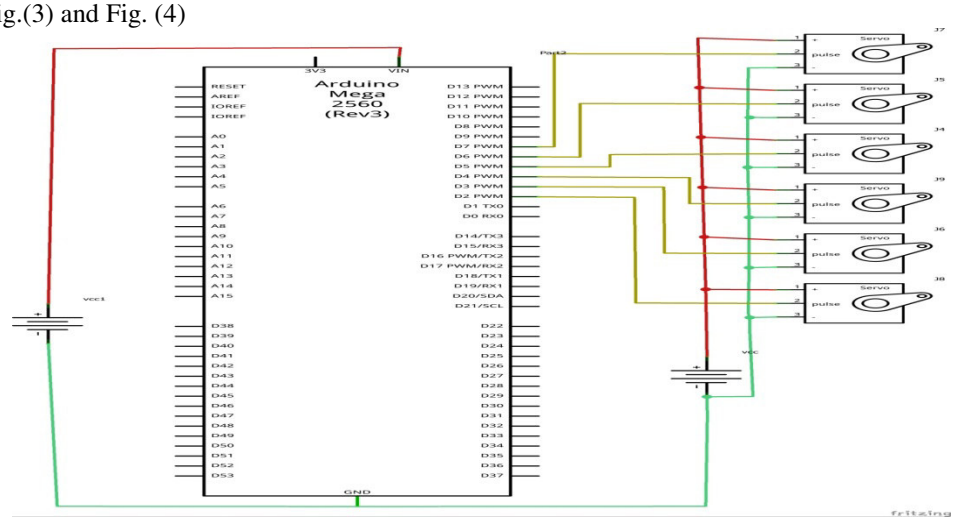

Fig.(3) Schematic Arm robot interface.

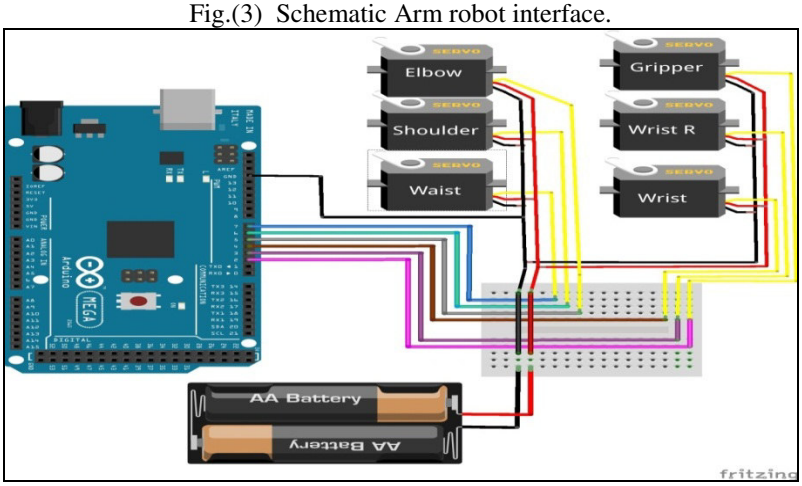

Fig.(4) Breadboard Arm Robot interface

5.2. The chassis interface

Rover 5 chassis was chosen to act as the base of the robot; Rover5 is a new breed of tracked robot chassis designed specifically for students. Fig.(5)and Fig.(6) show the interface Arduino mega with Rover 5.

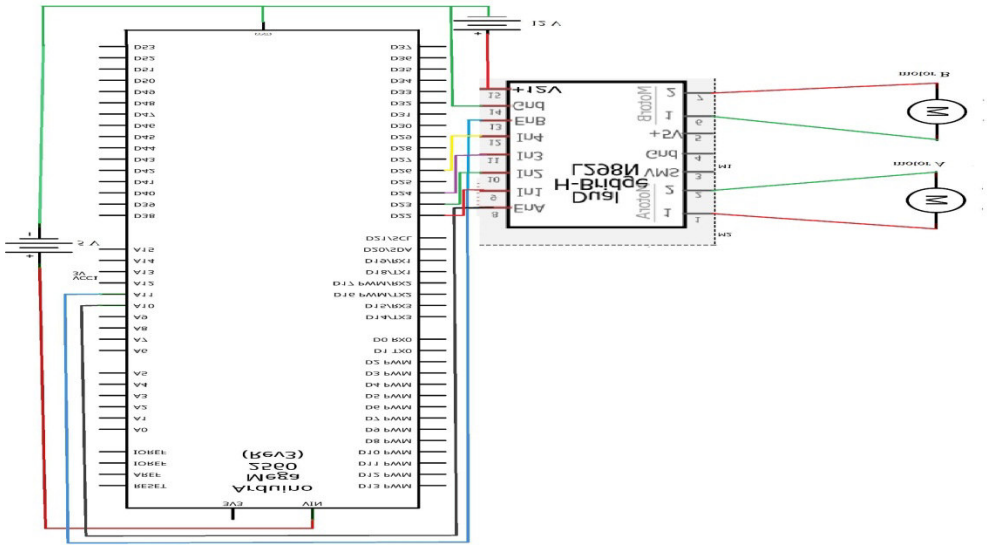

Fig (5) Schematic chassis interface.

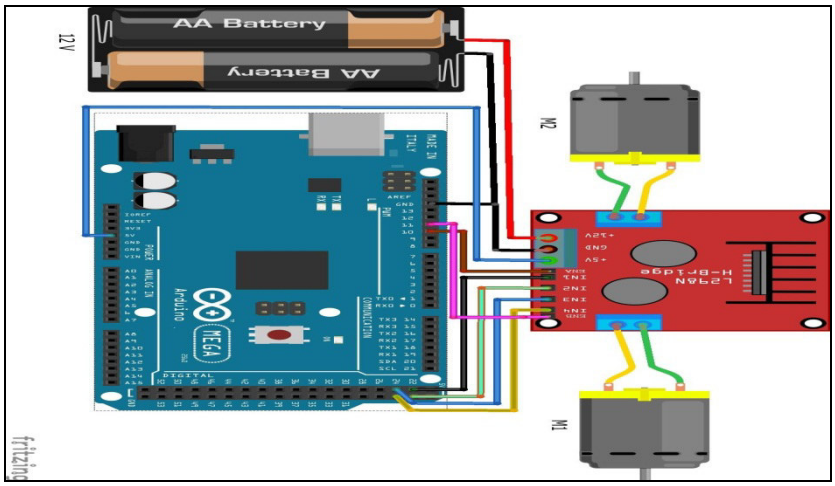

Fig.(6) Breadboard chassis interface

5.3. Pan/tilt interface

The pan/tilt servos are controlled in a very simple fashion. A PWM signal with a pulse width of 1.5ms corresponds to a centered position of the servo. An increase or decrease of the pulse width will increase or decrease the servo angle respectively up to a maximum of about ±90° from center position, the interface is shown in Fig.(7) and Fig.(8).

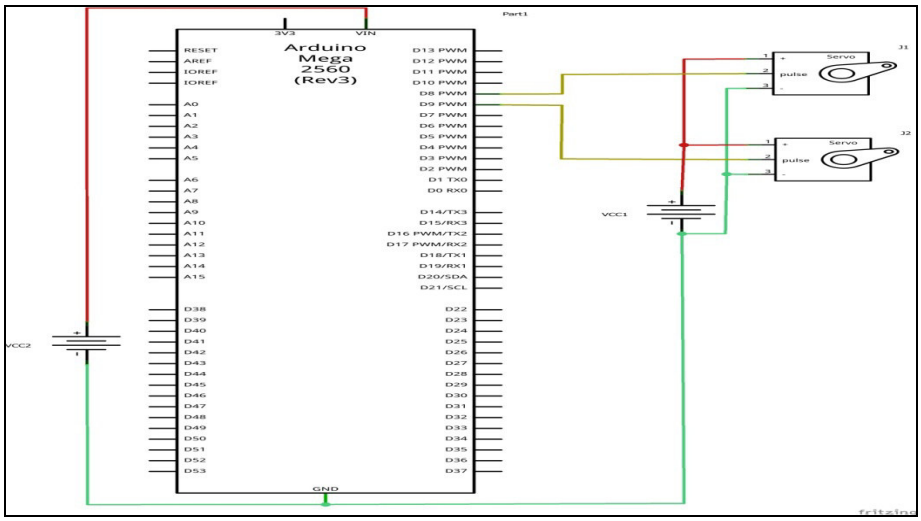

Fig. (7) Schematic pan / tilt interface.

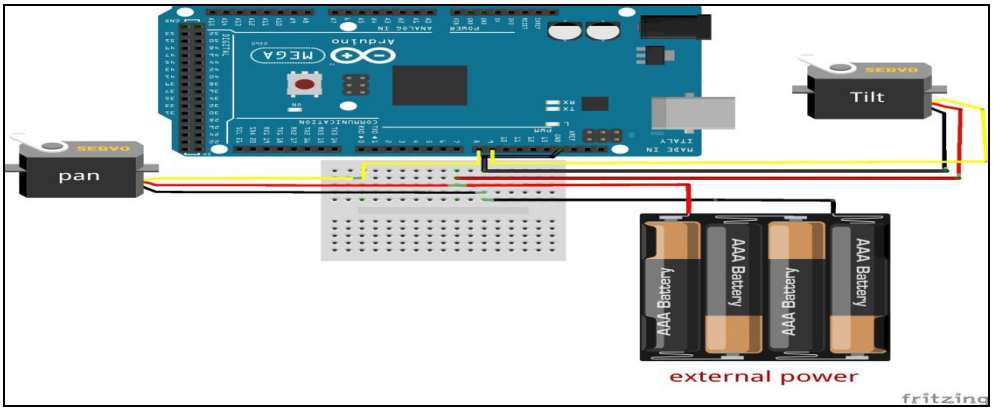

Fig. (8) Breadboard Pan/tilt interface.

6. Graphical User Interfaces (GUI)

Web page is the visible part of the programming, which has been programmed in Java Script, and by which the robot is fully controlled. It also can be seen from the camera image on Android phones and moved as needed, and from which it can also move the robot and control it fully, as shown in Fig.(9).

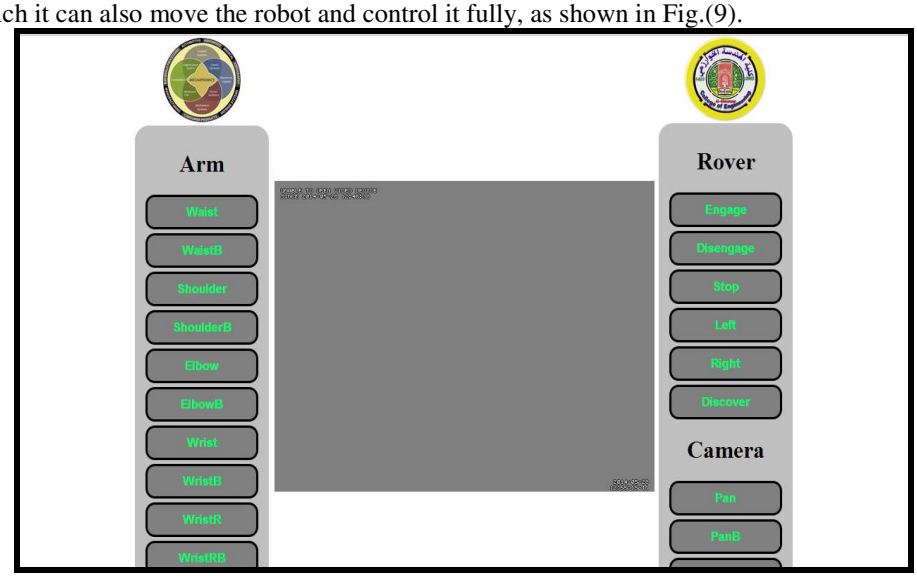

Figure (9) Graphical User Interfaces

7. System flowchart

The mobile robot system is consisting of two sections, theoretical and experimental work. Theoretical work involved building programs for graphical user interface using JavaScript language, server using python language , camera settings using motion program and arduino using C language. The experimental work consists of building the mobile robot by connecting the arm and camera above the robot and Work Interface between various electronic circuits. Fig.(10) illustrates the flowchart of the overall system.

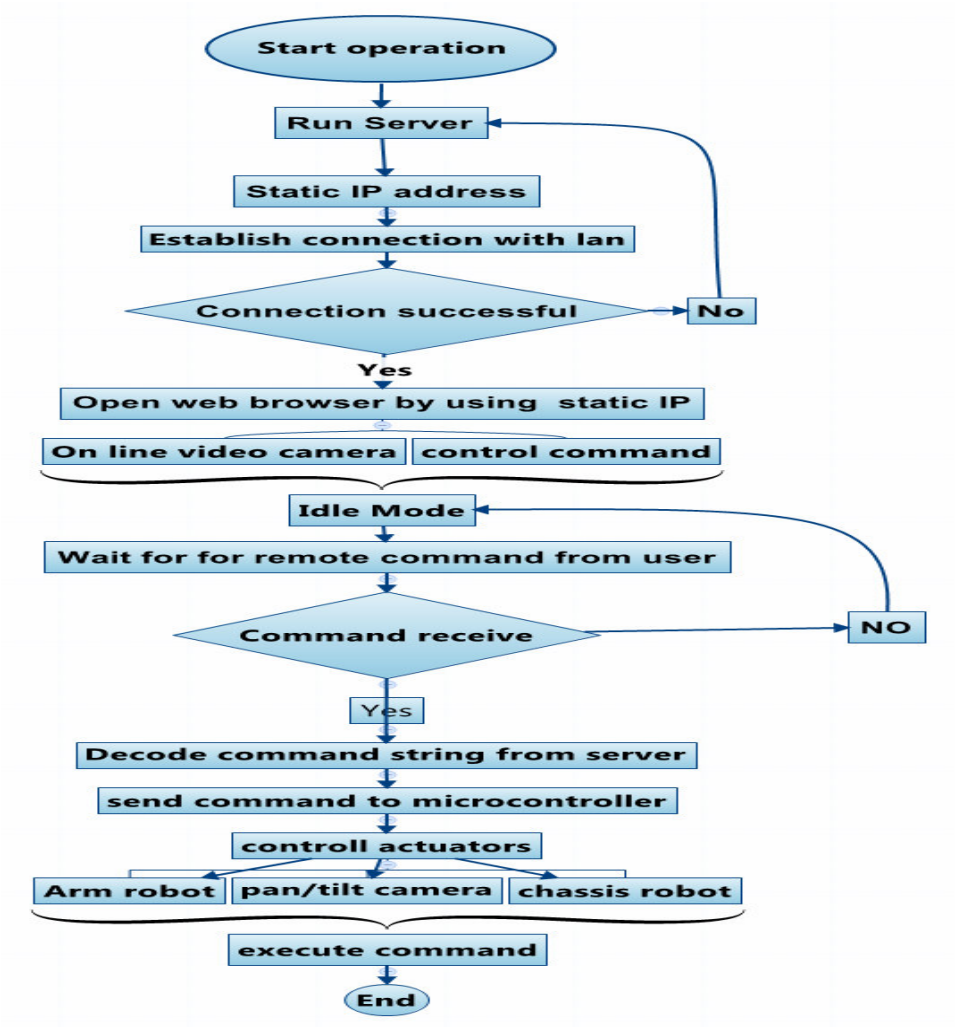

Fig.(10) flow chart of overall system

8. Wireless Communication Media

Wireless communication is a transfer of information between two or more points that are physically not connected. Wireless communications also permits services, such as long range communications, that are impossible or impractical to implement with the use of wires. The distances can be short, as a few meters, or long, ranging from a thousand to millions of kilometers from around the world. Wireless communication could be found in various types of fixed, mobile, and portable two ways radios, cellular telephones, Personal Digital Assistants (PDA), and wireless networking [8].

8.1 TCP/IP

The TCP/IP suite has become the industry standard method to interconnect the hosts, internet and networks. It is the engine behind the networks and Internet worldwide. Even though TCP/IP supports a host of applications, standard and nonstandard, the applications may not exist without the foundation of a set of core protocols [9].

8.2. Internet Protocol (IP) Addresses

Because TCP/IP networks are interconnected across the world, each computer on the internet must have a unique address (called an IP address) to make sure that transmitted data reaches the correct destination. Blocks of

addresses are assigned to organizations by the internet Assigned Numbers Authority (IANA). Individual users and small organizations may obtain their addresses either from the IANA or from an Internet Service Provider (ISP). The IP uses a 32 bit address structure [8].

9. Result and discussion

9.1. Complete designing robot

The robot mechanical structure is completed as shown in Fig.(13) and interface of wireless mobile robotic arm. The camera is mounted in the front of the mobile robot and can rotate in two axes (X &Y) in order to be of good visibility for the user and see objects in sides without the need of rotating the robot. When the robot is not working, the dimension of it will be (24.5 X 22.5 X 55) cm and the weight 3.25kg.

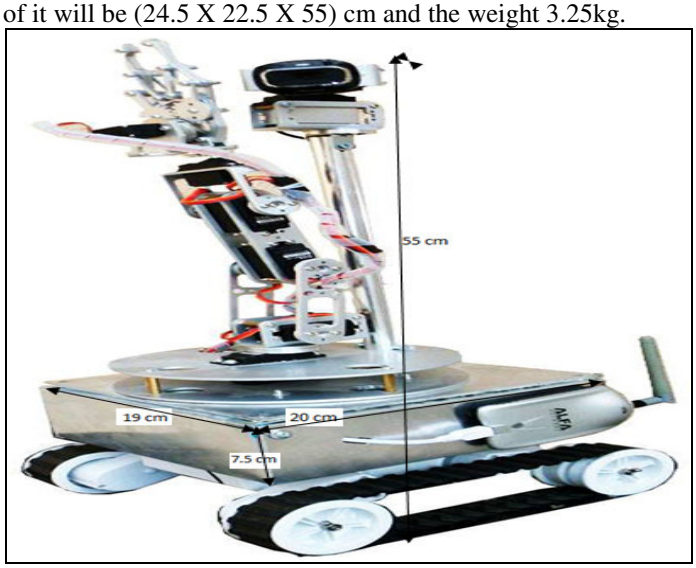

Fig. (13) Completed wireless mobile robotic arm.

9.2. Calculate Time Delay through Wireless Monitoring.

After designing the network for case studies, the configured network has been examined by sending the data packets from one host to another destination host in another location and receiving the destination host reply to these sent data packets. This test verifies the true design of the network since the wrong design does not enable the successful reply of the sent data packets over the designed network. The achievements of this test can be done by using the (ping) command in the originating data packet's host , by entering the destination host IP address in the command line prompt (Linux environment), and by writing the ping command followed by the IP address of the destination host. The time delay will be studied in each case separately.

The time delay can be calculated from the Ping instruction by taking the average time delays for any system that has its own IP address then the response of the system can be estimated. The average time can be calculated by the following equation.

$$\text{T delay (AV)} = \frac{\sum_{0}^{K} (\text{Round Trip Time})}{K}$$

Where:

Delay (AV): Average time delay,

K: Number of round trip test

*9.2.1.*Case Study 1: *calculate time delay in the wire LAN.*

In this case, the system has been linked with router, which is linked to the server (Raspberry Pi) through Ethernet cable.

9.2.2.Case Study 2: calculate time delay in Wireless LAN.

The *server* will be linked (Raspberry Pi) with router by using Alfa Wi-Fi card.The network is connected wirelessly.

9.2.3.Case Study 3: calculate time delay in WAN.

The time delay is calculated and studied through the World Wide Web for many different distances using public IP (can be obtained from the Internet service provider).

From case studies the results are summarized in the table(2).

Table (2) a summary of the cases that have been studied

	Min (ms)	Max(ms)	Avg (ms)
Case study 1	0.137	0.217	0.151
Case study 2	0.143	0.448	0.165
Case study 3			
Distance in Km	Min (ms)	Max (ms)	Avg (ms)
271	9	13	9
356	8	16	12
375	7	19	9
549	9	22	12

From table (2), it can be noticed that the value of average delay time in the case of wire LAN is **0.151** ms which is a very small value as it approaches largely the value of the time delay in the case of a wireless LAN **0.165** ms.

In the third case WAN, the time depends on the type of the network and the speed of the Internet. This time will cause a delay in monitoring and control of the robot system at the client site and cause distortion of response we note increase the value of the time delay and differ depending on the speed of the Internet and distance between the user and the robot system.

10. Conclusions

The main objective of this project has been achieved which is to build Internet mobile robot and to interface hardware and software for mobile robot arm controlled via the internet from any place, Controlling the robot does not require specific software**.** It just demands Internet service. Overlap does not occur when a command is sent to the robot from a server and an image is sent to a server from the robot. Easy to control without the need of any complex hardware and only the need of laptop or smart phone. Generally the robot server runs smoothly as planned and also the controller.By analyzing and comparing the time delay, it has been noticed that it would be very small in case of LAN (wire and wireless), the more increases in case of use the Internet the more increase the distance between the robot and the user .The increase depends on the distance, type and strength of the Internet package used. The use of a secure wireless connection (username and password) helps to minimize the penetration by hackers.

11. Recommendation

Working in the field of mobile robot is still open for research where there are many areas of study such as, mobile robot mechanical drive design according to its wheels, types of sensors used, types of controllers that are used, real world modeling…etc. As for the current research, the following suggestions are given for further developments of the work:

1- Add a solar cell to the robot to be able to charge itself automatically.
2- Add a second camera to the robot in order to increase the clarity and precision.
3- Use a joystick instead of a web page to control the robot allowing more flexibility, accuracy and ease in completing assigned tasks.
4- Using image processing to automatically treatment objectives robot at the same time.

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