pISSN: 2523-5729 eISSN: 2523-5739

Open Access
Full Length Article

ORIGINAL ARTICLE

Design of a Robot for Environmental Monitoring to Help in Search and Rescue

Muhammad Ahsan Memon[1], Muhammad Ali Nizamani[2], Malik Muhammad Saad Missen[3]

[1,2]Department of Electrical Engineering, ISRA University Hyderabad
[3]Department of Computer Science and IT, The Islamia University of Bahawalpur

ABSTRACT

Environment Monitoring Robots (EMR) are increasingly used to monitor the remote environment, either for surveillance due to security reasons or for inspection due to hazard area. There is need for such robotic system in our society to help humans safely inspect hazardous environment, for example inspecting a chemical industry site for detecting fire where such kind of robots are needed in order to help and inspect the remote site effectively, perform remote surveillance by detecting early unusual environmental conditions, and to affect the changes environment through a manipulator's arm. In this context an EMR, a Tele-operated mobile robot platform, which is controlled remotely through WIFI using a web-based application and also using a mobile-based android application, which also supports voice commands. The key aspect of the robot is the remote environment monitoring through various sensors, for example, using onboard cameras for visual monitoring and using a range of sensors such as temperature, humidity & flame sensors for detecting various hazards. The robot is also equipped with a manipulator's arm to effect changes in the remote environment and the robot performs autonomous obstacle avoidance using IR sensors during navigation. Overall, the designed system prototype has shown its potential capabilities for environment monitoring and surveillance through practical demonstrations.

Keywords: Environment Monitoring, Web-based control, Voice control, Android-based robot, Search and rescue

Author`s Contribution
[1] Data analysis, interpretation and manuscript writing, Active participation in data collection
[2] Conception, synthesis, planning of research and manuscript writing
[3] Interpretation and discussion

Address of Correspondence
Muhammad Ahsan Memon
Email: engr.ahsanmemon@gmail.com

Article info.
Received: Sep 15, 2017
Accepted: December 26, 2017

Cite this article: *Memon MA, Nizamani MA, Saad Missen MM. Design of Robot for environmental monitoring to held in search and rescue. J. inf. commun. technol. robot. appl.2017; 8(2):47-52.*

Funding Source: *Nil*
Conflict of Interest: *Nil*

INTRODUCTION

Usage of mobile robots have great value in the automated remote monitoring of chemical warehouses, nuclear power plants and industrial sites to prevent hazardous and leakages thus allowing increased safety for human operators [4]. During past decade, there has been an increased focus on using robotic technologies for security and safety of humans in the hazardous environments, for example, in Ship environment, nuclear power plant inspections and industrial environment monitoring [2].

The key aspect of such robot is the remote environment monitoring through various sensors, i.e.

using onboard cameras for visual monitoring, temperature sensor, humidity & flame sensors for detecting various hazards [3-5].

Besides surveillance of the environment, the mobile platform is equipped with a mani, pulsator's arm to effect changes in the remote environment, for example, picking an object for close inspection and also essential for performing search and rescue.The environment monitoring robot performs autonomous obstacle avoidance using IR sensors [8]. The need for an efficient robotic system is to handle the safety issues related to the hazardous industrial environment monitoring by humans are growing. Suthe ch robot needs to be the le to help inspect the remote site effectively, perform remote surveillance by detecting early unusual environmental conditions and react the changes environment through a manipulator's arm accordingly [9,10].

In this context, a robot system design focusing on efficient and effective controller design using web-based and Android-based control through WIFI. It will help monitor the remote environment, which may contain hazards, for efficient search and rescue operations using various sensors. It will support Tele-operations as well using a small manipulator to effect changes in the environment. Search and Rescue worker can also use the voice-based control of the system to give commands to the robot if needed. The designed system prototype has shown its potential capabilities for environment monitoring, search & rescue, and surveillance through practical demonstrations.

SYSTEM DESIGN

The system design consists of WIFI based web controlled remote and android application. Using the web-based application to control robots speed, direction, pan, tilt platform of the camera, manipulator arm and automatic obstacle avoidance using IR sensors, environment visualization using the camera, display temperature, humidity and flame sensors readings on the web, this robot is also controlled on voice using android application.

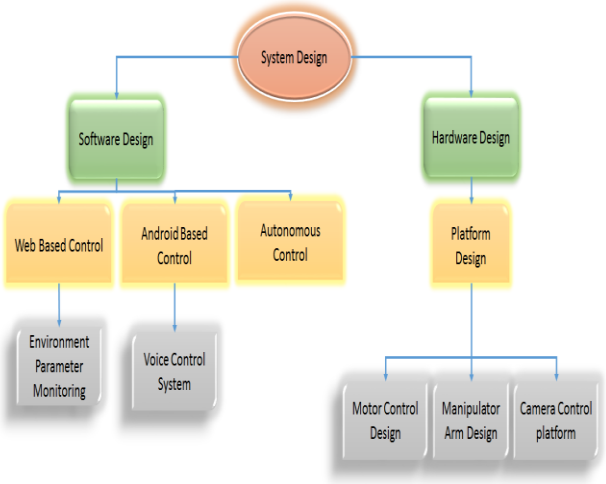

Fig. 1 system design block diagram

A. Motor Control Design

The designed system uses wireless web-based remote over WIFI. The webpage could be further accessed using devices i.e. computer/mobile with given Raspberry Pi IP address, the command executed in the webpage will be sent to the main controller (Raspberry Pi) which in turn will turn on that particular device. The working principle of this system is shown in figure 2. Web-based motor control is important and main part of this project, through motor control mobile platform can be moved from one place to another place. In this system the motors are controlled from wireless web remote, the commands are sent from the main controller to H-bridge. H-bridge takes the signal in form of Pulse width modulation from the controller. Through PWM signal the speed and direction of DC motors can be controlled.

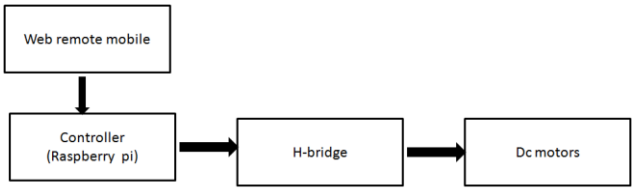

Fig. 2 motor control system

B. Camera Control Platform

The camera control system is used because from the certain angle we cannot get accuracy and efficiency in monitoring for that we have used Pan and Tilt platform to visualize the whole situation without turning the robot.

Figure 3 shows the working of camera control system, in this figure two Servo motors are used, one for pan (direction) and other for tilt angle. Both work in 0 to 180 degrees, it is controlled from the web-based remote. When the operator presses a button on the webpage, it executes the command from the web to the controller and then controller transmits it to the servo motor.

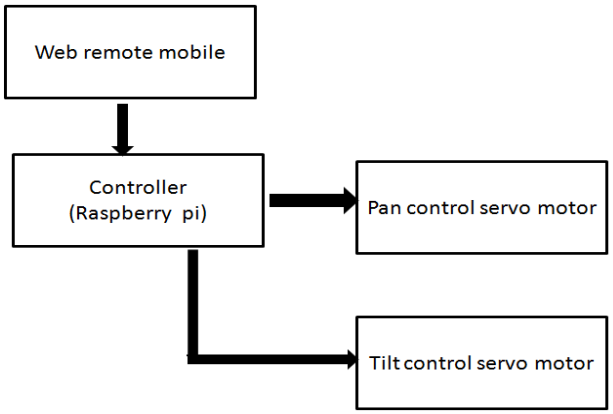

Fig. 3 Camera control system

C. Manipulator Arm Design

The robotic arm is important, it is used to pick and place material. It can also be used to pick objects from the hazardous environment. The manipulator's arm is used with the Environment Monitoring Robot, which is attached in front of the robot. This manipulator arm control system is based on "three degrees of freedom". Working principle is shown in figure 4 each degree has one servo motor. Three degree has Elbow with up and down angle, Wrist which rotates from (0 – 90 – 180 and from 180 back to 90 – 0) and clamper which open and close to grip a small object. The command executes from web-based remote to the controller and transmits to a servo motor which is placed in each degree of freedom.

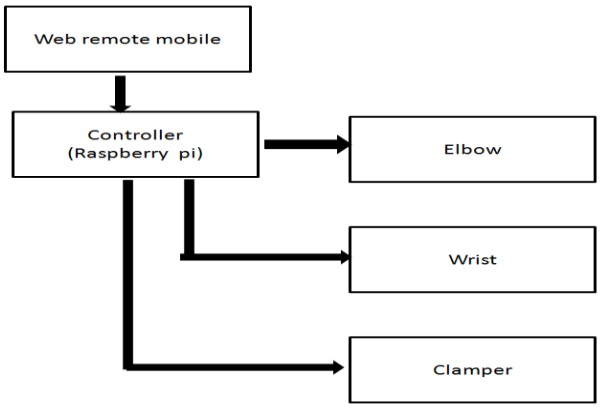

Fig. 4 Manipulator arm control system

D. Autonomous control system

The automatic control system is a great significance value in the robotic system, in this system robot takes the decision itself. The robot detects an obstacle and takes decision according to the specified condition which is programmed. We use automatic control system because the operator is not available at every time for a survey of the environment.

This system is able to work only for detecting an obstacle and change the way according to programmed conditions. Figure 5 show working system of the autonomous control system, the system has two IR sensors one placed on Left-side and another on Right side. The automatic command can be executed from a webpage, when it is executed IR sensors checks for an obstacle, if there is no obstacle robot move straight if there is an obstacle on any side of the robot it moves back for 5 seconds then turn according to programmed command after that go straight, this process repeats continuously.

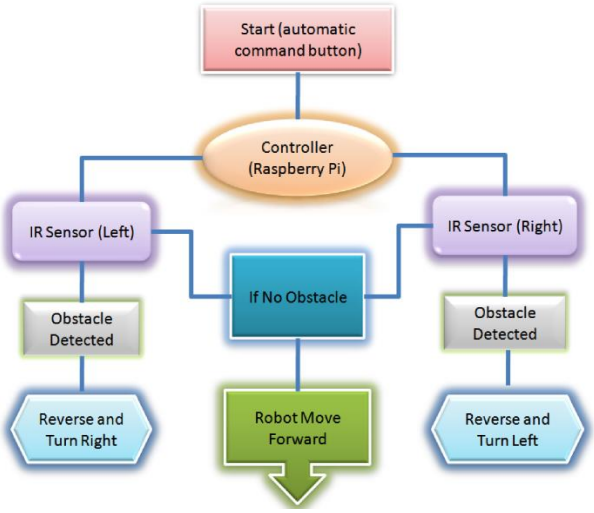

Fig. 5 automatic control system

E. Voice Control System

In the voice control system, the environment monitoring robot is controlled by voice using android application. Voice commands change the behavior of robot according to the programming. The voice given is detected from Google server for accuracy then it is executed to perform a particular task. Table 1 shows various command for voice control system.

TABLE 1: Voice commands	
Voice controlled system	Voice commands
Test commands	Intro, Spec
Controls	Automatic, Manual
Robot directions	Forward, Back, Left, Right
Manipulator Arm control	Up, Down Rotate Center, Rotate Right, Rotate Left Open, Close
Camera control system	Camera Left, Camera Right, Camera Center, Camera Top, Camera Down
LED control	Light on, Light off

F. Environment Parameters Monitoring

Environment parameters are one of a most important factor in this project, the main purpose is to measure environmental parameters through different sensors because these sensors indicate about a different situation in the environment and show the sensor reading on web-based remote and the camera provides live streaming video.

Figure 6 shows working process of different sensors, Camera gives live video signal from the environment to controller and controller transmit a signal to the web, also temperature, humidity and flames sensors measure the environment and sensors provide readings to controller board and controller transmit these readings to the webpage.

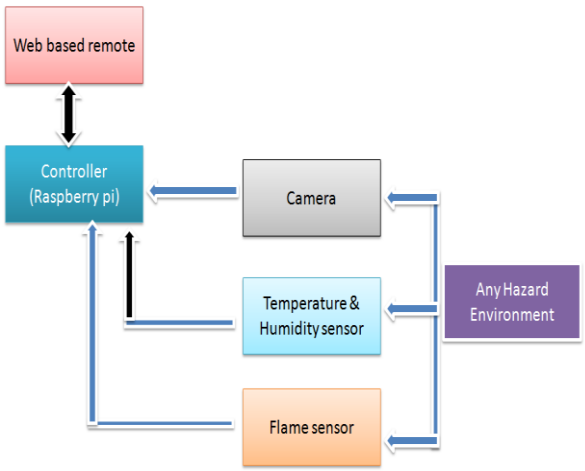

Fig. 6 Environment parameters flow system

G. Software Design

Software design is based on web-based application and android application. In this web-based application remote establishment process, we use HyperText Markup Language (HTML) for webpage development, a shell script to control actuator, python language for Environment parameters and Autonomous control.

In the development of android application using android studio software to create a voice-controlled application. In this application direct voice command is given to control the robot. The application has voice control capability and also manual control.

SYSTEM OPERATION

Complete system operation is shown in following flow chart figure 7. The android app/ web-based application remote developed in Raspberry Pi board, it works on WI-FI signals and internet. First, the robot is connected with raspberry pi on WI-FI than open web-based remote application on the browser using raspberry pi IP and for voice control, we use android application open THIS application on the android phone.

The command system executes from web-based remote to the main controller, H-bridge, and dc motors are used for the controlling direction and speed of mobile platform. A buck converter provides fixed 5V to servo motors it controls the pan, tilt camera direction controlling platform and manipulator arm.

Raspberry Pi camera and environment sensors take readings from current environment and display results on the web based remote. IR sensors used for automatic control system it detects obstacles and changes the direction according to the programming.

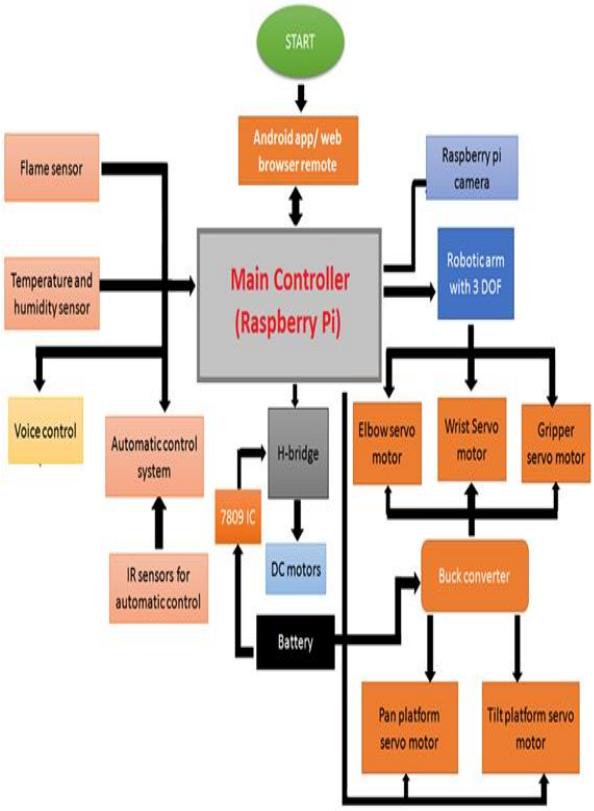

Fig. 7 Complete system operation chart

RESULTS AND DISCUSSION

The working of EMR towards the completion of the final module we observed the behavior of EMR as per requirement. We tested all motions and control systems. The robot accurately follows the command.

We perform the direction of pan, tilt platform, which work in up, down, left and right directions, manipulator's arm performs three degrees of freedom. Up, down movement of Elbow, clockwise, anticlockwise directions of the wrist and open, close conditions of the gripper.

It accurately performs the voice command and automatic control system. The EMR display accurate temperature, humidity and flame sensors readings on the web based remote. The camera provides online video streaming on web based remote and android application.

The EMR know as Tele-operated mobile platform robot. It used for surveillance of hazardous environment it has a small size, low power consumption, and low cost so it is more efficient. The figures below show the final working module controlling through web and monitoring parameters on the webpage.

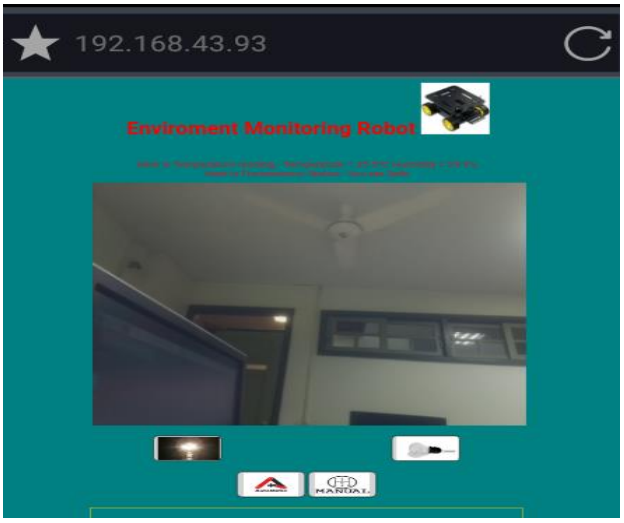

Fig. 7 monitoring results

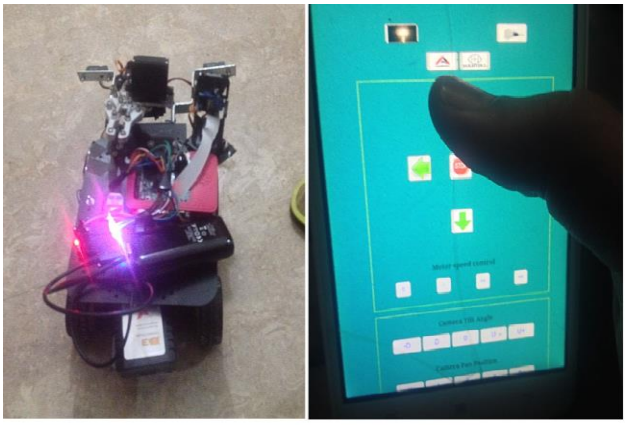

Fig. 8 Direction controlling of emr through the web.

CONCLUSION

The final designed system has been demonstrated to be working well and the developed mobile robotic platform helps perform in remote monitoring of environment safely and efficiently. The main advantages are controlling robot operations seamlessly through the web based application and as well as with a mobile phone using an Android-based app. The Android app also supports voice activation of various commands. The main environment parameters observed for the detection of unusual and hazardous activity are temperature, humidity, and fire. Also, the robot is able to perform basic pick and place tasks using a simple manipulator arm and navigation used autonomous obstacle avoidance capability.

However, the final designed and developed has some limitations, for example, the camera view is limited

to front only, need for further sensors to effectively monitor the environment, and perform complicated operations using the manipulator's arm.

FUTURE WORK

In the future, we aim to remove the following limitations. The arm complexity will be increased, which is currently limited by platform payload capacity. Increase the payload capacity of the platform. Improve the control aspects of software design. Add more environment parameter sensors, Automatic GPS following.

REFERENCES

1. Ishibash Maya, Iida Michihisa, and Suguri Masahiko, "Remote Monitoring of Agricultural Robot using Web Application," Faculty of Agriculture, Kyoto University, Kitashirakawa Oiwake-cho, Sakyo-ku, Japan August 27-30, 2013.
2. Kim Seung, Kim Hoi, Seo Chil and Lee Gyu "Development of Tele-Operated Mobile Robot in Nuclear Power Plants," Advanced Robotics Lab, Korea AIO MLC Energy Research Instlwt e, P.O. Box 105, Yu son g, Ta ejon 305 -600, Korea, 2001.
3. Trincavelli Marco, Reggente Matteo and Coradeschi Silvia "Towards Environmental Monitoring with Mobile Robots," IEEE/RSJ International Conference on Intelligent Robots and Systems, Acropolis Convention Center Nice, France, Sept-22 to 26, 2008.
4. Qian Kui, Song Aiguo and Bao Jiatong "Small Teleoperated Robot for Nuclear Radiation and Chemical Leak Detection," School of Energy and Power Engineering, Yangzhou University, Yangzhou, China, 15 Jun 2012.
5. Marques Lino and Dunbabin Matthew "Robotics for Environmental Monitoring," Ieee Robotics & Automation Magazine, 24 February 2012.
6. Chauhan Ranjeeta and Kumar Anup, "Voice Controlled Robot," Department of Electronics and Computers Engineering Dronacharya College of Engineering, Gurgaon-123506, India, 2014.
7. Dabhi Mosam, Modh Adarsh and Mishra Lakshmi "Wireless Network Controlled Robot using a Website, Android Application or Simple hand Gestures," Applied Mathematics and Humanities Department, Sardar Vallabhbhai National Institute of Technology, Ichchhanath Mahadev Dumas Road, Surat – 395 007 (Gujarat), India, June 11, 2015.
8. Jin Ming, Schiavon Stefano and Spanos Costas "Automated mobile sensing: Towards high-granularity agile indoor environmental quality monitoring," Electrical Engineering and Computer Sciences Department, University of California, Berkeley, CA 94720, USA, 2 November 2017.
9. Ersahin Gonca and Sedef Herman "Wireless Mobile Robot Control with Tablet Computer," World Conference on Technology, Innovation and Entrepreneurship, Turkey, 2015.
10. Osch Osch, Bera Debjyoti and Zeegers Henk "Tele-operated service robots," Technische Universiteit Eindhoven, Mechanical Engineering Department, Den Dolech 2, Eindhoven, The Netherlands, 19 June, 2013.
11. Papcun Peter, Zolotova Iveta and Tafsi Karim "Control and Teleoperation of robot khepera via Android Mobile Device through Bluetooth and WI-FI," International Federation of Automatic Control, 2016.
12. Rehman Adeel, Necsulescu Dan and Sasiadek Jurek "Robotic Based Fire Detection in Smart Manufacturing Facilities," Department of Mechanical Engineering, University of Ottawa, Canada, 2015.