***IJACSSE**Journal*- *International Journal of Advanced Computer Systems and Software Engineering*

E-ISSN: 2716-5256 online

Design And Control Of Autonomous Robot Using Gesture Based Intuitive Interaction

Asad A. Latif[a], Muhammad Ali Nizamani[a], G. M. Shoro[a], Faheem A. Abassi, Bisharat R Memon[a],*

[a] *Institute of Information & Communication Technology, University of Sindh, Jamshoro, Pakistan.*

* *Corresponding author:* ma.nizamani@usindh.edu.pk

ARTICLE HISTORY

Received: 15 September 2020
Accepted: 24 October 2020
Published Online: 28 October 2020

KEYWORDS

Industrial robot
Leap motion control
Human robot interaction

ABSTRACT

Robots now a days are performing tasks, which were complex and difficult for humans, for example, working in nuclear power plant, in chemical industries and even in outer space. Some of these tasks are autonomous (obstacle avoidance etc.) and some are remotely controlled by humans. In general, a robotic platform with manipulator arm has several joints and is difficult to control remotely, especially in a rescue mission, through joystick or a computer keyboard. A natural and intuitive way to interact with a robot is using gestures. As leap motion controller provides a simple and effective method to accurately track the movement of human hands and fingers, can be used to provide intuitive control of robot. In this work, we show a design a robotic platform which is controlled by hand gestures being tracked by the leap motion controller. The left hand is used for controlling platform mobility, using gestures to provided different motions, for example, moving forward and moving backwards and the right hand is used for controlling arm for pick and place tasks. The developed robot can be used for remote monitoring of the difficult environment and affect changes to it via a manipulator arm. Also, it can autonomously avoid obstacles using Ultrasonic sensors. Overall, the designed system prototype has shown its potential capabilities for environment monitoring and surveillance through practical demonstrations using gestures.

1.0 INTRODUCTION

Robots are now a days being used in wide areas of application such as for nuclear power plant inspection [1-3], for bomb disposal [4], even for disinfecting hospitals and providing meals to contiguous patients [5-8]. These robots can be controlled manually or automatically. In manual control a good level of precision is required (for bomb disposal operations, surgical procedures etc.) and it can be done through force feedback methods or using remote joysticks. In a search a rescue scenario or even in a scenario where touching a contaminated surface might affect operator a gesture based approach is more natural and intuitive. In this work our aim is to design and develop an intelligent mobile robot supported with a manipulator arm for search and rescue using gesture based control. Embodiment means using human

The gesture based robot control involves different methods, by porting a glove on a human hand or using a camera with other sensor to interpret hand gestures directly. In a robot controlled by wearing gloves equipped with an accelerometer, the robot perceives the motion of human hands through it. Robot detects position of human hand and acts accordingly. [9-10] use accelerometer to control a robot, in [9] they used an accelerometer to control two dc motors in all four directions and in [10] a 3-axis accelerometer wrist band is used to detect hand gestures and control a robot car. The gestures were interpreted using Hidden Markov Models (HMM) technique. It was effective but needs more gestures and also limited for an application to a remote search and rescue mission.

There are many different ways the robot can be controlled directly with the gestures, using cameras, infrared cameras, ultrasonic sensors and a combination of all these [11-15]. In [11] an android based wireless system was used to control a robot. Basically it involved interpreting the gestures using a camera and an ultrasonic sensor, though it needs to be modified to control a robot remotely and also can have issues with color segmentation. Another important non-invasive robot control is using depth cameras and IR sensor in combination. In [12] Microsoft Kinect was used to detect human gestures for controlling a robot, Kinect is gives high depth data for whole body and is very effective in detecting hand and finger positions. [13] used Asus Xtion (similar to Kinect is also able to give depth information) to detect human hands, though it was limited as did not detect the static or dynamic gestures.

In this work used leap motion controller to detect gestures and control both the robotic platform and robot manipulator arm with it, where as in [14] it was used only for controlling robot arm and [15] used it for virtual automation. Also, our work includes autonomous obstacle avoidance capability, an important aspect in a tele-opearted robot [16], In next section we discuss the methodology used.

2.0 METHODOLOGY

Leap Motion Controller, as shown in figure 1, is used as primary sensor to track and detect motion of both right hand and left hand, it also able to track he finger movements. It gathers data at 200 frame/sec and has a range of 2.5cm to 60 cm, using two infra-red cameras. The main design includes a software component, that receives input from Leap motion controller, connected to a laptop or a PC, and it interprets the gestures and communicates to an Arduino based controller. The Arduino sends respective commands to robot (base or arm), the final design is shown in the figure 2.

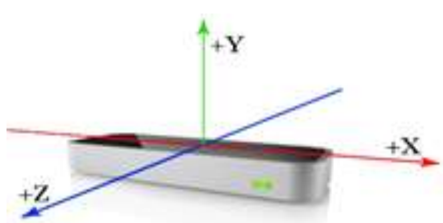


Figure 1: Leap Motion Controller

This configuration keeps the human operator independent of robot workspace, as Leap Motion Controller tracking the hand and fingers remotely and robot operation can be controlled remotely.

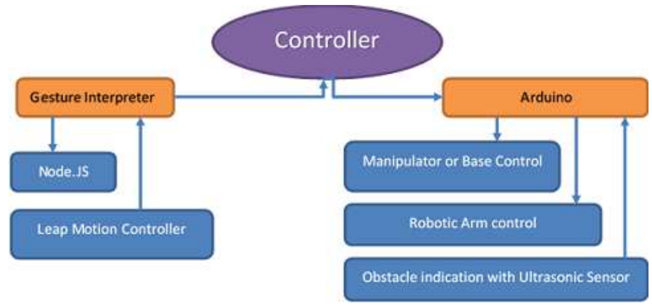


Figure 2: System Working Diagram

The designed robot is based on two parts. First is robot base/ platform and second is robotic arm. The robot platform is moveable and its mobility is controlled by using the left hand gestures to provide different robot motions, for example, moving forward, backward and left, right. Its block diagram is shown in figure 3. Robotic arm is controlled using gestures from the right hand for pick and place tasks, its working shown in figure 4. The table 1.0 summarizes the gestures and the respective robot base or arm motions. Also, it performs autonomous obstacle avoidance taking input ultrasonic sensors and using a simple algorithm, that on detection of obstacles uses a predetermined strategy of evasion.

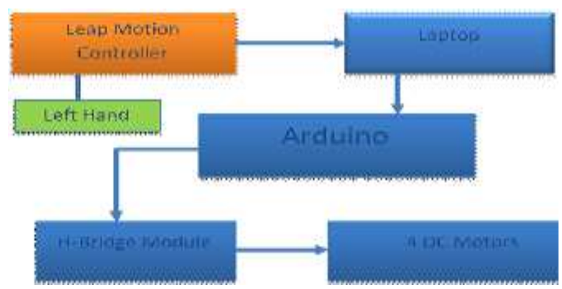


Figure 3: Block diagram for Robotic platform

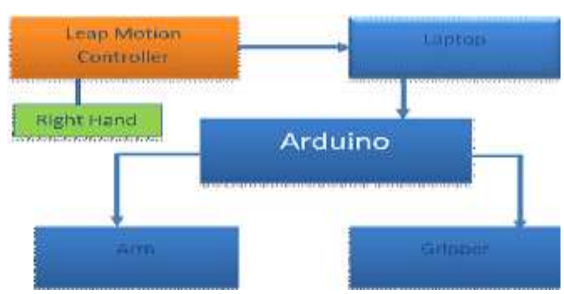


Figure 4: Block diagram for Robot Arm

Table 1.0: Hand Positions and Gestures

Left Hand Position	Base Direction	Right Hand Position	Arm Direction
-X -axis	Left	-X -axis	Left
+X -axis	Right	+X -axis	Right
-Z -axis	Forward	-Z -axis	Forward
+Z -axis	Backward	+Z -axis	Backward

The robot base is a 4-wheel chassis, as shown in figure 5, consists of 4 dc motors for moving; forward, backward, left and right. The motor speed and the direction are control by the L298 H-Bridge motor driver and the driver is connected with Arduino board. Arduino sends signal to the motor driver to move forward, reverse, left and right direction the PWM pins of the driver is used for control the speed. The robot arm is a a 4-DOF (degree of freedom) manipulator, as shown in figure 5, consisting of a base, shoulder, elbow and a gripper. The gripper is a Claw type to hold the object. In robotic arm 4 servo motors are used to move each joint individually.

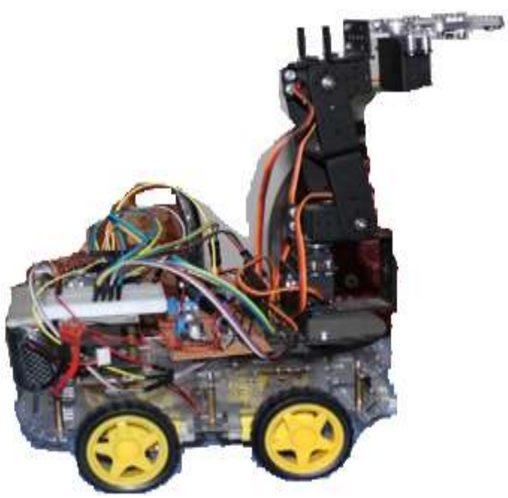


Figure 5: Robot with base and arm

The robot base is controlled using left hand via Leap Motion controller, as operator moves his left hand above it, the detected motion is interpreted by the gesture module and relevant motion commands executed on the robot base through Arduino. Also, operator controls the robot arm using the right hand. As the right hand moves, it is tracked by controller and relevant motion for the arm are calculated using the inverse kinematics of manipulator in the gesture interpreter module using the method similar in [17]. Trigonometric functions are used to calculate the joint angels of arm and these angles are send to the servo then arm moves with the movement of hand. The gripper tool is controlled through right hand fingers. The robotic arm is used for pick and place task by the operator. Finally, the ultrasonic sensors help detect obstacles and using a simple evasion strategy, autonomously avoid obstacles, in case operator does not see the obstacles.

3.0 RESULTS AND DISCUSSION

The final designed system has been demonstrated to be working well and the developed mobile robotic platform with robotic arm is easily controlled using gestures via Leap Motion, the figure 6.0 shows the human operator controlling the robot arm through right hand and the figure 7.0 shows the raw values of hand position when hand is placed on Leap motion controller. The operator is able to move both the base and the arm in different directions and pick and place the objects using gestures only

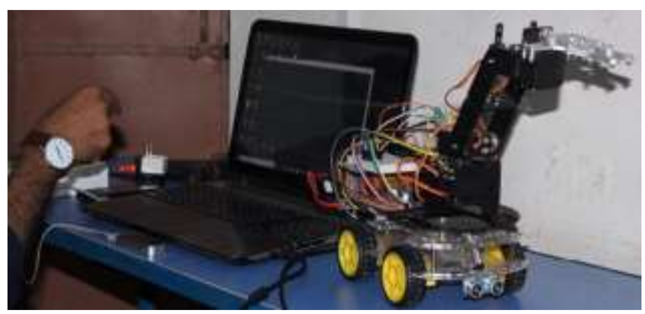
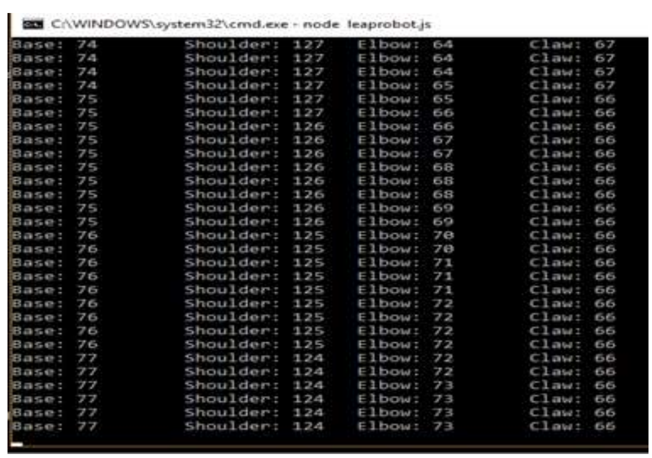


Figure 6: Operator controlling the robot arm using right hand



```
C:\WINDOWS\system32\cmd.exe - node leaprobot.js
Base: 74    Shoulder: 127   Elbow: 64    Claw: 67
Base: 74    Shoulder: 127   Elbow: 64    Claw: 67
Base: 74    Shoulder: 127   Elbow: 64    Claw: 67
Base: 74    Shoulder: 127   Elbow: 65    Claw: 67
Base: 75    Shoulder: 127   Elbow: 65    Claw: 66
Base: 75    Shoulder: 127   Elbow: 66    Claw: 66
Base: 75    Shoulder: 126   Elbow: 66    Claw: 66
Base: 75    Shoulder: 126   Elbow: 67    Claw: 66
Base: 75    Shoulder: 126   Elbow: 67    Claw: 66
Base: 75    Shoulder: 126   Elbow: 68    Claw: 66
Base: 75    Shoulder: 126   Elbow: 68    Claw: 66
Base: 75    Shoulder: 126   Elbow: 68    Claw: 66
Base: 75    Shoulder: 126   Elbow: 69    Claw: 66
Base: 75    Shoulder: 126   Elbow: 69    Claw: 66
Base: 76    Shoulder: 125   Elbow: 70    Claw: 66
Base: 76    Shoulder: 125   Elbow: 70    Claw: 66
Base: 76    Shoulder: 125   Elbow: 71    Claw: 66
Base: 76    Shoulder: 125   Elbow: 71    Claw: 66
Base: 76    Shoulder: 125   Elbow: 71    Claw: 66
Base: 76    Shoulder: 125   Elbow: 72    Claw: 66
Base: 76    Shoulder: 125   Elbow: 72    Claw: 66
Base: 76    Shoulder: 125   Elbow: 72    Claw: 66
Base: 76    Shoulder: 125   Elbow: 72    Claw: 66
Base: 77    Shoulder: 124   Elbow: 72    Claw: 66
Base: 77    Shoulder: 124   Elbow: 72    Claw: 66
Base: 77    Shoulder: 124   Elbow: 73    Claw: 66
Base: 77    Shoulder: 124   Elbow: 73    Claw: 66
Base: 77    Shoulder: 124   Elbow: 73    Claw: 66
Base: 77    Shoulder: 124   Elbow: 73    Claw: 66
```

Figure 7: The raw values of hand positions from Leap Motion Controller

The gesture based control provides intuitive control of the robot and is suitable for remote search and rescue operation. The operator can sit next to his laptop and control the robot using hand gestures only and without needing to touch any physical control, especially helpful if environment is highly contagious. Camera to monitor environment can be used using Raspberry PI, which is currently not included. Also, there is an issue of jerk in the motion of the robot, more visible with the arm. It can be smoothed using a jerk controller.

4.0 CONCLUSION

The envisioned system is successfully implemented on a prototype robotic platform with arm. The operator is able to control the base and using gesture via Leap Motion Controller. The gesture control is natural as does not involve nay wearable (wrist band, gloves etc.) and is more precise. The mobile plate form has also the autonomous obstacle avoidance capability. Overall, designed robot allows human operators to intervene successfully in the remote difficult environments. However, the prototype has some limitations about smooth arm motion without jerk, in future this issue will be addressed.

Acknowledgement

Authors wish to acknowledge, Faculty of Engineering & Technology, University of Sindh for assistance to carry out this project work.

References

[1] Seo, Y.-C., Jeong, K., Shin, H., Choi, Y., Lee, S.-U., Noh, S., … Cho, J. W. (2016). A Mobile Robotic System for the Inspection and Repair of SG Tubes in NPPs. International Journal of Advanced Robotic Systems. https://doi.org/10.5772/62248

[2] Li, J., Wu, X., Xu, T., Guo, H., Sun, J., & Gao, Q. (2017). A novel inspection robot for nuclear station steam generator secondary side with self-localization. Robotics and biomimetics, 4(1), 26. https://doi.org/10.1186/s40638-017-0078-y

[3] irvik Sen, K.K. Singh, A.W. Patwardhan, S. Mukhopadhyay, K.T. Shenoy, CFD-PBM simulations of a pulsed sieve plate column, Progress in Nuclear Energy, Volume 111, 2019, Pages 125-137, ISSN 0149-1970, https://doi.org/10.1016/j.pnucene.2018.10.012.

[4] Lisle, D. (2020). Making safe: The dirty history of a bomb disposal robot. Security Dialogue, 51(2–3), 174–193. https://doi.org/10.1177/0967010619887849

[5] P. Chanprakon, T. Sae-Oung, T. Treebupachatsakul, P. Hannanta-Anan and W. Piyawattanametha, "An Ultra-violet sterilization robot for disinfection," 2019 5th International Conference on Engineering, Applied Sciences and Technology (ICEAST), Luang Prabang, Laos, 2019, pp. 1-4, doi: 10.1109/ICEAST.2019.8802528.

[6] Guang-Zhong Yang, Bradley J. Nelson, Robin R. Murphy, Howie Choset, Henrik Christensen, Steven H. Collins, Paolo Dario, Combating COVID-1 - The role of robotics in managing public health and infectious diseases, Science Robotics 25 Mar 2020: Vol. 5, Issue 40, eabb5589 DOI: 10.1126/scirobotics.abb5589

[7] Hans Buxbaum, Sumona Sen, Lisanne Kremer, An Investigation into the Implication of Human-Robot Collaboration in the Health Care Sector, IFAC-PapersOnLine, Volume 52, Issue 19, 2019,Pages 217-222, ISSN 2405-8963, https://doi.org/10.1016/j.ifacol.2019.12.100.

[8] Karabegović I., Doleček V. (2017) The Role of Service Robots and Robotic Systems in the Treatment of Patients in Medical Institutions. In: Hadžikadić M., Avdaković S. (eds) Advanced Technologies, Systems, and Applications. Lecture Notes in Networks and Systems, vol 3. Springer, Cham.

[9]. R. Vashisth, A. Sharma, S. Malhotra, S. Deswal and A. Budhraja, "Gesture control robot using accelerometer," 2017 4th International Conference on Signal Processing, Computing and Control (ISPCC), Solan, 2017, pp. 150-153.

[10] Xing-Han Wu, Mu-Chun Su and Pa-Chun Wang, "A hand-gesture-based control interface for a car-robot," 2010 IEEE/RSJ International Conference on Intelligent Robots and Systems, Taipei, 2010, pp. 4644-4648.

[11] A. Ganihar, S. Joshi, G. Rahul, R. Hongal and U. Mudenagudi, "Android based wireless gesture controlled robot," 2014 International Conference on Advances in Electronics Computers and Communications, Bangalore, 2014, pp. 1-4.

[12] S. Amatya and S. Petchartee, "Real time kinect based robotic arm manipulation with five degree of freedom,"

2015 Asian Conference on Defence Technology (ACDT), Hua Hin, 2015, pp. 1-6. doi: 10.1109/ACDT.2015.7111574.

[13] Grzejszczak T., Mikulski M., Szkodny T., Jędrasiak K. (2012) Gesture Based Robot Control. In: Bolc L., Tadeusiewicz R., Chmielewski L.J., Wojciechowski K. (eds) Computer Vision and Graphics. ICCVG 2012. Lecture Notes in Computer Science, vol 7594. Springer, Berlin, Heidelberg.

[14] Sarmad Hameed, Muhammad Ahson Khan, Bhawesh Kumar,Zeeshan Arain and Moez ul Hasan "Gesture Controlled Robotic Arm using Leap Motion" Indian Journal of Science and Technology, Vol 10(45), DOI: 10.17485/ijst/2017/v10i45/120630, December 2017.

[15] S. Y Kanawade, Bhavana Gojare, Kalpana Bodhak, Shubham Surve "Leap Motion Control Using Virtual Automation" International Journal of Advance Research, Ideas and Innovations in Technology, Vol 3 issue 2, 2017.

[16] C. Passenberg, A. Peer, and M. Buss, "A survey of environment, operator, and task adapted controllers for teleoperation systems," Mechatronics, vol. 20, no. 7, pp. 787–801, 2010.

[17] A. A. Mohammed and M. Sunar, "Kinematics modeling of a 4-DOF robotic arm," 2015 International Conference on Control, Automation and Robotics, Singapore, 2015, pp. 87-91, doi: 10.1109/ICCAR.2015.7166008.