Materials Today: Proceedings xxx (xxxx) xxx

Contents lists available at ScienceDirect

Materials Today: Proceedings

journal homepage: www.elsevier.com/locate/matpr

Gesture controlled dual six axis robotic arms with rover using MPU

P. Prakash *, C. Dhanasekaran, K. Surya, K. Varunny Pius, A.S. Vishal, S. Vignesh Kumar

Department of Mechanical Engineering, Vels Institute of Science, Technology & Advanced Studies (VISTAS), Chennai, India

A R T I C L E I N F O

Article history:
Received 21 May 2019
Received in revised form 13 June 2019
Accepted 22 June 2019
Available online xxxx

Keywords:
6 axis dual arm
Gyro meter
MEMS
Gesture control
Simple controller

A B S T R A C T

The purpose of this work is to create a gesture controlled dual 6 DOF robotic arm with rover, to perform critical works like bomb, mine defusing and other operations where work like human nature are required. The dual 6 DOF arm make 12 + the rover motion makes 4 = 16 operations can be controlled with the use of single modified ps2 joystick, in which a 6 DOF arm and the rover of the robot can be operated simultaneously. MPU-9250 is mounted on the joystick to recognize the roll and pitch of the joystick along with push button interaction.

1. Introduction

There are many methods which are used to control robotic arm by using different sensors, some of them are using Flex sensor [6], Vision-based hand-gesture [3,4], Accelerometer-based control [2,5] and using the leap motion controller [1,7]. From gone through literature, mostly the researchers investigated about single robotic arm and their controlling methods which are complex [8–18]. The use of MPU along with modified ps-2 joystick button interaction makes an efficient and simple controller which allows anyone to operate the robot without giving any special training to the operator.

The scope of this project work is to operate a fully functional 12 DOF dual robotic arm in a mobile platform with a modified right hand operated joystick, which consist of single GY-9250 mounted in it to detect the roll and pitch of joystick made by the operator. In this project one of the two arms can be operated simultaneously along with the mobile platform, which makes it a way easy to operate in more critical areas. A secondary left arm joystick is used to control the left arm separately, which gives the operator a full control over the robot. By using left and right arm joystick both together the operator can get full access over the robot (i.e. left arm, right arm and the mobile platform) and control all the operation of the robot simultaneously. A single arm robot which performs the same task requires more time to accomplish the work, where dual armed robots with gesture recognition joystick can efficiently use their two arms to accomplish the work with less time consuming. The material used to build the arm is mild grade aluminum, which makes the arm light in weight and also inexpensive.

2. Related works

In the present world gesture control method for controlling robotic arm are popular and robots with two arm with various DOF are evolving. So the proposed robot is not a new one, but the strategy used to control the 12 DOF robot with mobile platform is different. Robotic arms are widely used in various fields such as medical, defense, industries and research purpose. There are various research and developments are going on to improvise the control method of robotic arms with less effort and complexity using different sensors and technics. Few popular work in this field and their demerit are discussed below.

2.1. LEAP motion controller [1,7]

LEAP motion controller uses two IR cameras and three IR LEDs to detect the motion of hand, palm and fingers in three dimensions. The two IR cameras captures images at maximum resolution of 200 frames per second. The detection range of LEAP motion controller is limited to 2 feet's above the device. The USB controller in the device has its own local memory to store the sensor data to perform resolution adjustment if required. LEAP motion controller are creating a new trend in VR gaming.

* Corresponding author.
E-mail address: prakash1033.se@velsuniv.ac.in (P. Prakash).

https://doi.org/10.1016/j.matpr.2019.06.702
2214-7853/

The LEAP motion controller uses cameras to detect the operators had and hence requires its own space for the operator to perform gestures and for the device to recognize it. The device uses IR led to track the hand, so a hand overlap or hand moved out of detection area the device loses its track on hand.

2.2. Accelerometer-based control of an industrial robotic arm [2,5]

This work describes the use of accelerometer to control industrial robots. The system consist of two wearable device consist of accelerometer for both left and right arm of the operator. The right arm accelerometer is used to control the robotic arm and the left arm accelerometer is used to activate or deactivate the system. The operator uses his both the hand to operate the robotic arm. When the user uses his left arm and activate the system, the system detects the gesture of operator's right arm and compares it with preprogrammed data and starts the motion of the arm.

The operator has to use his both hands to operate a single robotic arm and the operator has to keep his left arm horizontally oriented during the time of operation.

2.3. Real-time robotic hand control using hand gestures [3,4]

This work uses camera to get from live video of operators hand and detects the gesture of operator's hand by capturing and searching 3 frame per second. The processes of this work starts from capturing 3 frames per second, the normalizing and smoothening it. Then the software scans for the gesture of operator, if it finds the gesture, the software crops the gesture made by the user and compares the gesture with its database, once it finds the matching gesture from it database it executes the task which is assigned for the gesture.

This work uses camera to detect the gesture of the operator, thus it requires a sufficient lighting to capture the gesture made by the operator.

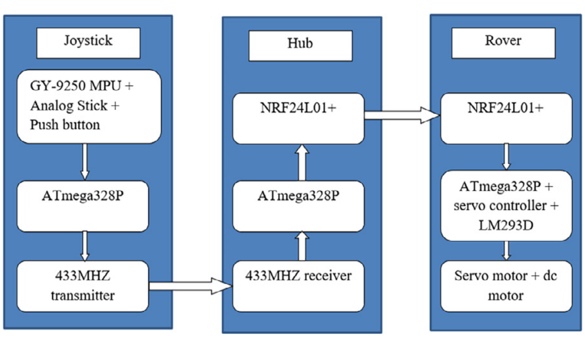

Fig. 1. Block diagram of proposed mode.

3. Proposed model

3.1. System description

The proposed model consists of three individual sections (Fig. 1). They are

- Joystick
- Hub
- Robot

The first section is the joystick section, which is used to operate the robot remotely. A ps-2 joystick is modified according to the project. A motion sensor MPU-9250 is mounted inside the joystick to detect the roll and pitch of the joystick during the operation. The processing IC for all the section is an ATMega328P. A 433 MHz transmitter is used to transmit the data from the joystick to the hub. The hub is the second section which used to increase the range of operation of robot in open space. The hub section consists of 433 MHz receiver which receives the data from the hub, which is then transmitted through the 2.4 GHz NRF24L01 transceiver to the robot. The 2.4 GHz NRF24L01 transceiver in the hub is used to extend the range of operation of the robot up to 1 km. The third section is the robot, which is operated remotely. The robot receives the data from the hub through the 2.4 GHz NRF24L01 transceiver and processes it with the ATMega328p microcontroller. The processed data is the sent to the 16 channel 12-bit servo controller to control the arm servos and lm293d motor controller to control the direction of the robot (Fig. 2).

3.2. Block diagram

The joystick section consists of modified PS-2 joystick with GY-9250 MPU for detecting the roll and pitch of the joystick made by the operator. The ATMega328P detects the input of the operator by using the pushbuttons along with the roll and pitch of the joystick and transmits it to the hub through the 433 MHz transmitter (Fig. 3).

The hub section consists of 433 MHz receiver to receive the data from the joystick and transmits it through the 2.4 GHz NRF24L01 transceiver for the extended range of communication. By adding a secondary hub the range of range of operation of the robot can be extended (Fig. 4).

The robot section consist of 2.4 GHz NRF24L01 transceiver to receive the data from the hub. The ATMega328P microcontroller controls the servo controller which is responsible for controlling the arm servo and lm293d IC which controls the motion of the robot (Fig. 5).

3.3. Methodology

The primary controller is designed for right hand operation which makes it easy to operate, as humans are naturally adapted

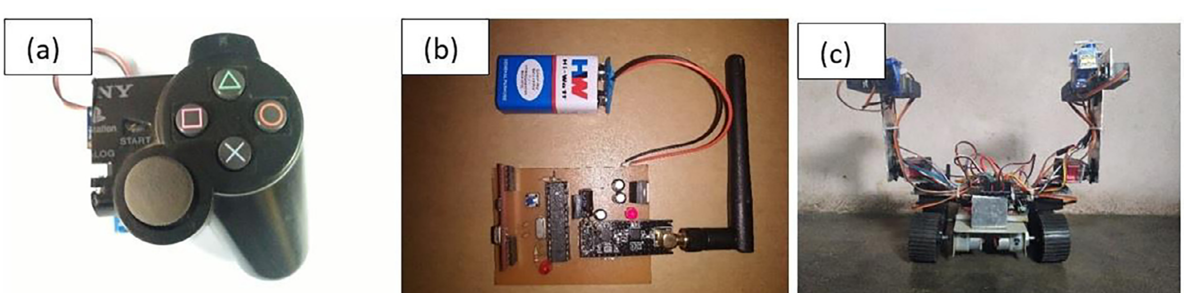

Fig. 2. (a) Right arm joystick; (b) Hub; (c) Dual arm rover.

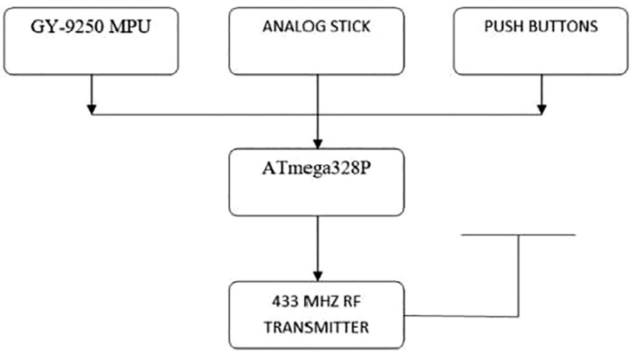

Fig. 3. Block diagram of joystick.

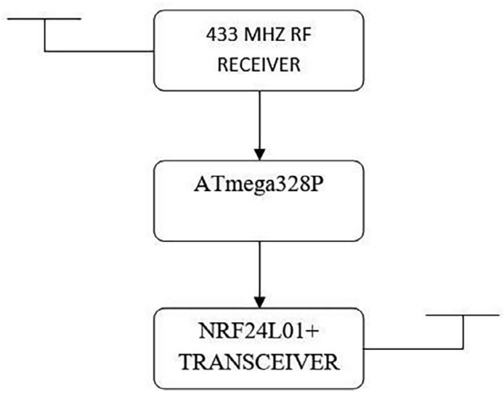

Fig. 4. Block diagram of hub.

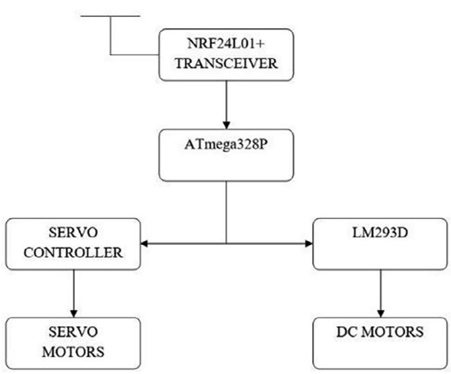

Fig. 5. Block diagram of robot.

to work with right hand expect some people. The joystick has three modes. They are

- Arm-1 mode (right arm mode)
- Arm-2 mode (left arm mode)
- Driving mode

The default mode of the joystick is Arm-1 mode, which is right arm mode. The normal roll and pitch of the joystick controls the two servos of the 6 DOF arm. The roll and pitch along with the press of R1 button of joystick will control the other two motion of the 6 DOF arm and the R2 button combined with roll and pitch of the joystick will controls the 5 servo and the gripper of the robot. The "□" button in the controller is used to shift the controller to left arm mode. All the operation are same as the right arm mode, instead of controlling the right arm the controller will now control the left arm. The "O" button is used to shift back to the right arm mode. The "△" button is used to reset the position of the arm, which sets every servos in both right and left arm to 90° angle. The "X" button in the controller is used to turn "OFF" and "ON" the controller. The analog stick in the controller is used to control the direction of the robot. The arm of the rover can be controller simultaneously along with the motion platform of the robot, which means the robots one arm can be controlled while driving the mobile platform of the robot.

A secondary left arm joystick is used to control the left arm individually, which make it possible to operate the two 6 DOF arm and the mobile platform of the robot can be operated at the same time continuously. All the operations of the robot can be controlled easily without stopping or disturbing the other operation of the robot.

4. Operation strategy

4.1. Arm control

The project described in this project has two arm, each has 6 DOF. Each servo motion is limited to minimum range of 0° to maximum range of 180°, which can be extended further if required. The initial position of each servos in the arm is set to 0°. The increment and decrement value of servos is set by i++; and i−−; in the code. As long as the operator holds the controller in increment position the angle of the servo increases with a predefined delay and vice versa for the decrement value. The delay can also be customized according to the skill of operator (Fig. 6).

- The servo used for the 1st axis is SR-6120MG
- The servo used for 2nd, 3rd and 4th axis is MG996R
- The servo used for 5th axis and the gripper is SG90 9g micro servo

4.2. Controller operation

The robot has 6 DOF dual arm in which each servos has its own degrees of freedom. The microcontroller in the rover receives the data from the modified PS-2 joystick (controller). The controller uses the MPU GY-9250 to detect the roll, pitch and button interface of the joystick made by the operator and compares it with per defined data then transmits the matching data to the robot via hub (Fig. 7).

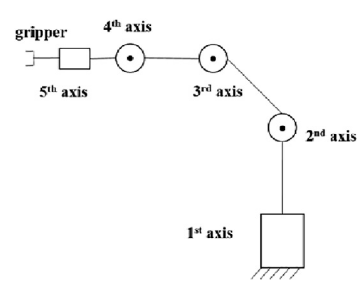

Fig. 6. 2D image of 6 DOF arm used in robot.

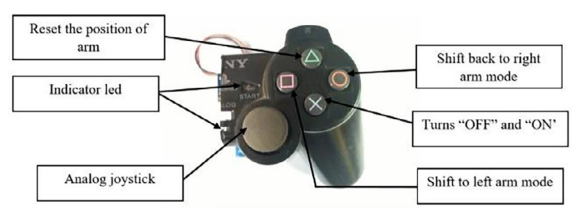

Fig. 7. Controller keys explanations.

Please cite this article as: P. Prakash, C. Dhanasekaran, K. Surya et al., Gesture controlled dual six axis robotic arms with rover using MPU, Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2019.06.702

4.3. Control strategy of right arm

The fig below shows gestures used to operate the robot is experimentally demonstrated below.

4.3.1. Gestures to control 1st and 2nd axis of the right arm (Figs. 8–12).

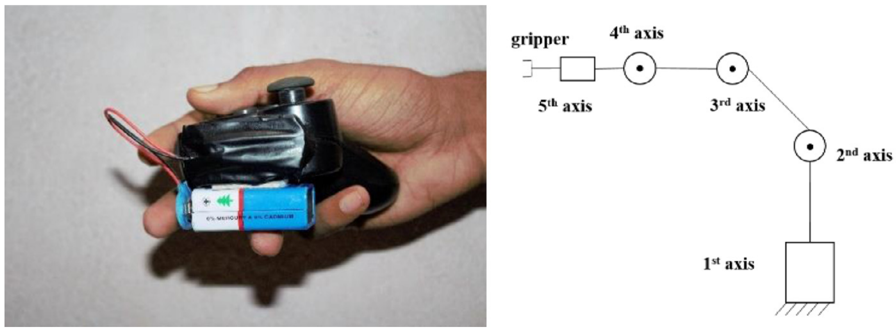

Fig. 8. Gesture – 1 stable. No motions in the arm.

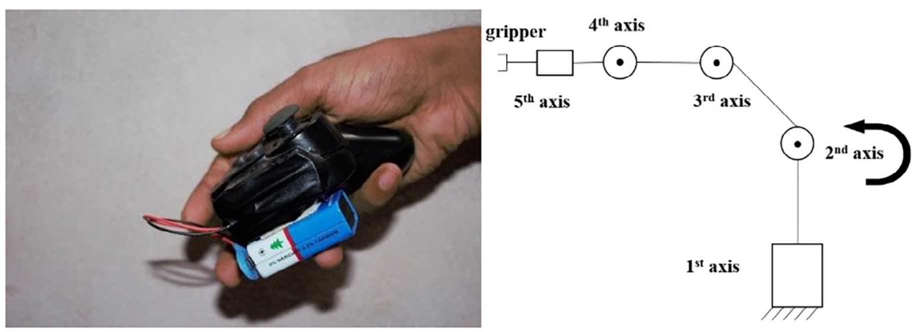

Fig. 9. Gesture – 2 moves the 2nd servo forward.

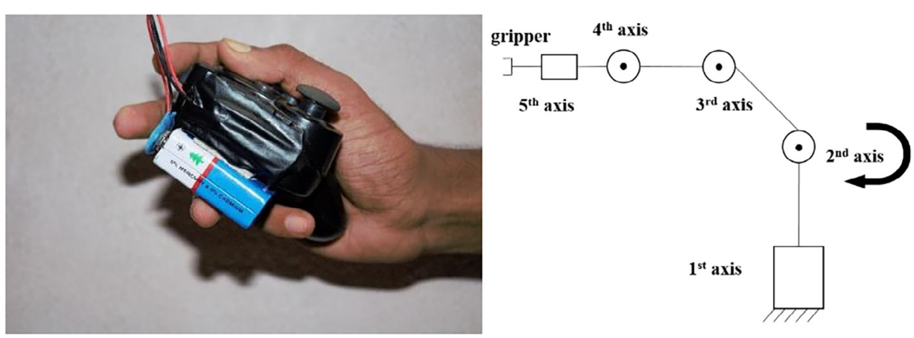

Fig. 10. Gesture – 3 moves the 2nd servo in reverse direction.

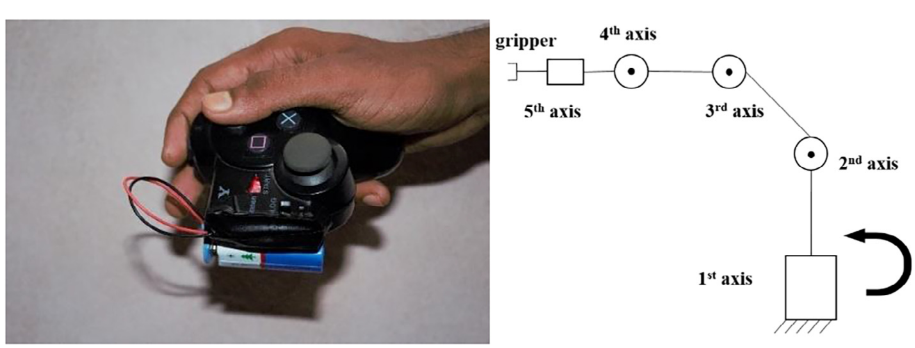

Fig. 11. Gesture – 4 moves the 1st servo in anti-clock wise direction.

Please cite this article as: P. Prakash, C. Dhanasekaran, K. Surya et al., Gesture controlled dual six axis robotic arms with rover using MPU, Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2019.06.702

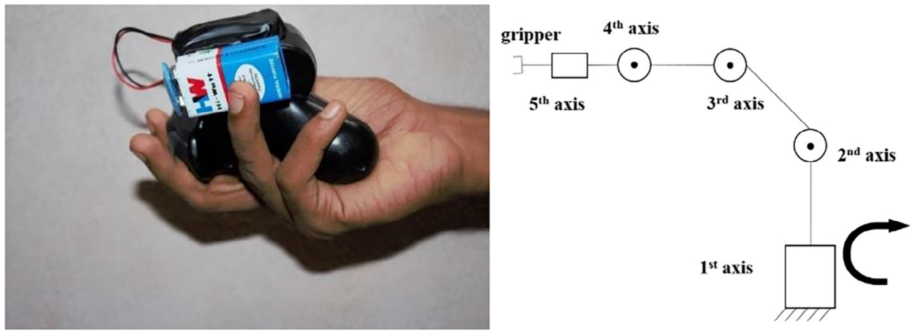

Fig. 12. Gesture – 5 moves the 1st servo in clock wise direction.

4.3.2. Gestures combined with R1 and R2 button

The R1 and R2 keys are shown below (Fig. 13)

Gesture -6: gesture – 2 accompanied with the R1 button of the joystick actuates the 3rd axis of the servo (Fig. 14)

Gesture -7: gesture – 3 accompanied with the R1 button of the joystick actuates the 3rd axis of the servo (Fig. 15)

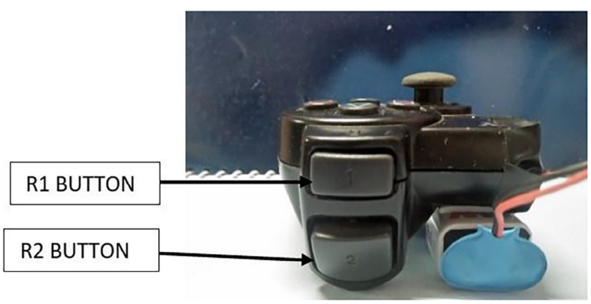

Fig. 13. The above image shows the R1 and R2 button of the joystick.

Gesture -8: gesture – 4 accompanied with the R1 button of the joystick actuates the 5th axis of the servo (Fig. 16)

Gesture -9: gesture – 5 accompanied with the R1 button of the joystick actuates the 5th axis of the servo (Fig. 17)

Gesture -10: gesture – 2 accompanied with the R2 button of the joystick actuates the 4th axis of the servo (Fig. 18)

Gesture -11: gesture – 3 accompanied with the R2 button of the joystick actuates the 4th axis of the servo (Fig. 19)

Gesture -12: gesture – 4 accompanied with the R2 button of the joystick closes the gripper (Fig. 20)

Gesture -13: gesture – 5 accompanied with the R2 button of the joystick opens the gripper (Fig. 21).

4.4. Control strategy of left arm

The "□" button is used to shift the controller to left arm mode and the "O" button is used to shift back to the right arm controlling mode (Fig. 22). All the gestures are same for both arm controlling. A secondary left arm joystick can also use to control the left arm individually.

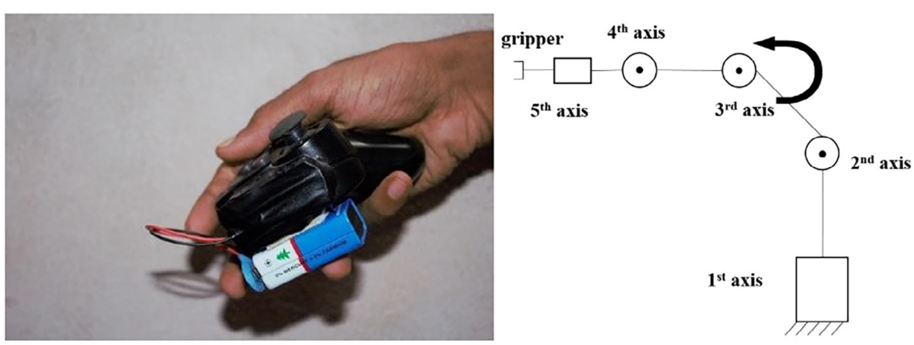

Fig. 14. Gesture 6 rotates the 3rd axis servo in down wards direction.

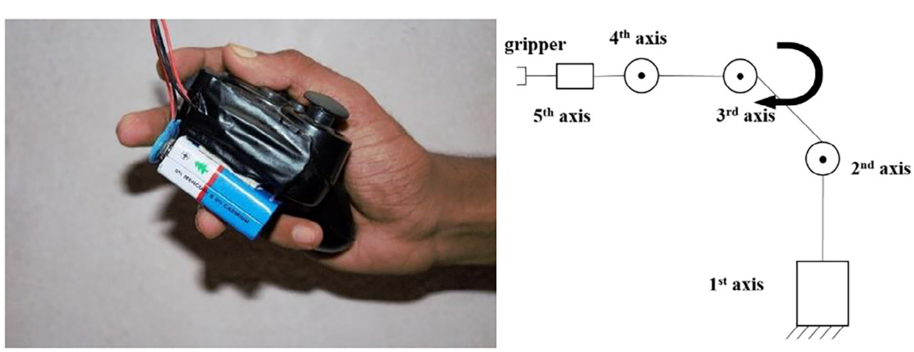

Fig. 15. Gesture 7 rotates the 3rd axis servo in up wards direction.

Please cite this article as: P. Prakash, C. Dhanasekaran, K. Surya et al., Gesture controlled dual six axis robotic arms with rover using MPU, Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2019.06.702

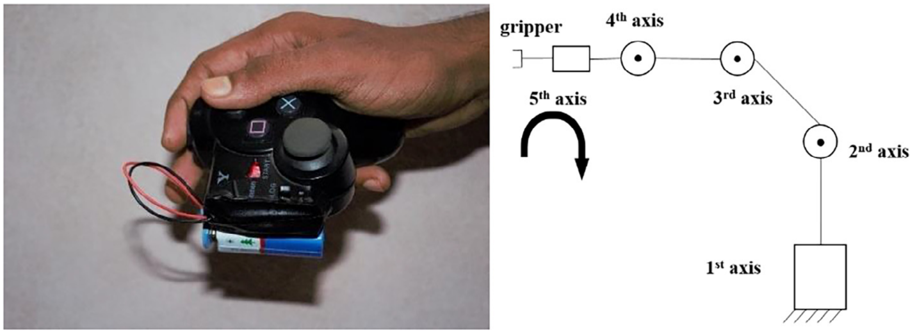

Fig. 16. *G*esture – 8 moves the 5th axis servo in anti-clock wise direction.

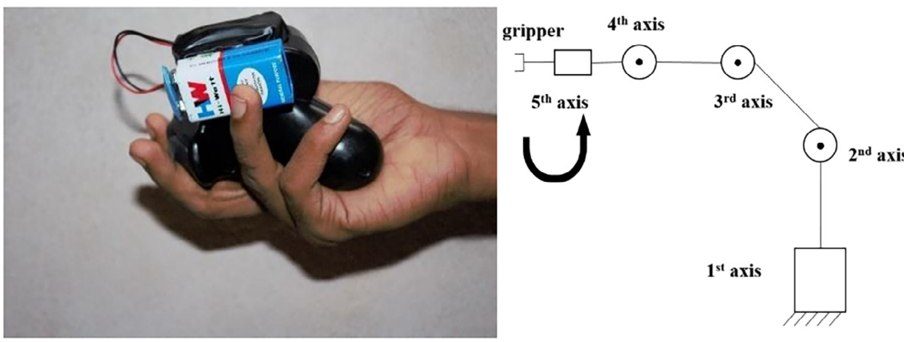

Fig. 17. *G*esture – 9 moves the 5th axis servo in anti-clock wise direction.

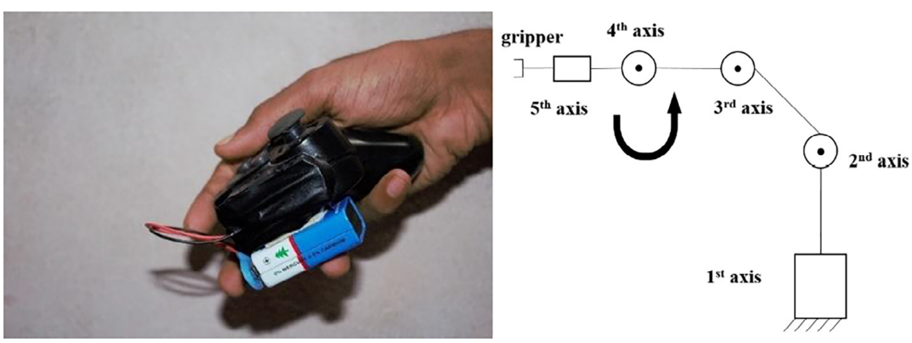

Fig. 18. Gesture 10 rotates the 4th axis servo in down wards direction.

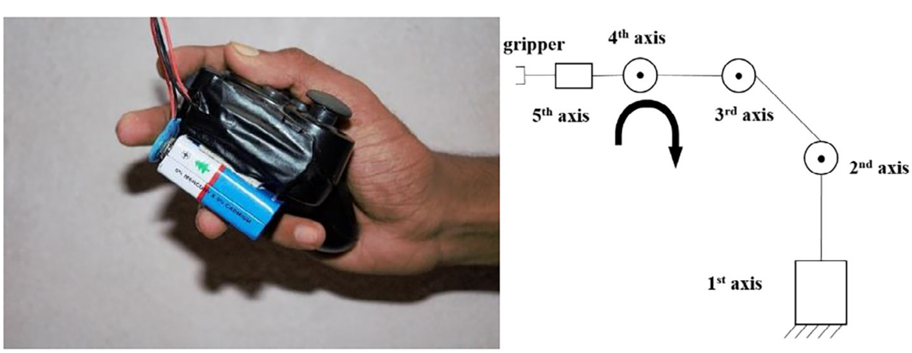

Fig. 19. Gesture 11 rotates the 4th axis servo in up wards direction.

Please cite this article as: P. Prakash, C. Dhanasekaran, K. Surya et al., Gesture controlled dual six axis robotic arms with rover using MPU, Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2019.06.702

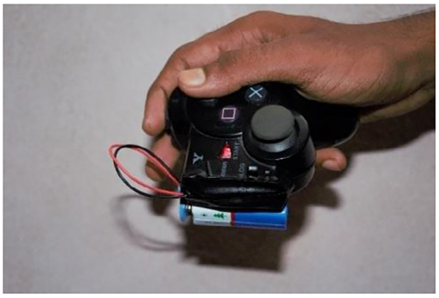

Fig. 20. Gesture 12 closes the gripper.

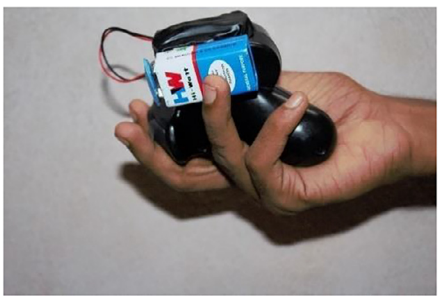

Fig. 21. Gesture 13 opens the gripper.

Fig. 22. Left and right arm mode shifting.

4.5. Driving mode strategy

The analog stick in the joystick is used to control the mobile platform of the robot along with the arm. Both the arm and the mobile platform can be controlled at the same time. The analog stick have a middle button on it centre, which is used to shift the joystick mode to motion controlled driving mode.

In motion controlled driving mode the gesture 2, 3, 4 and 5 are used to control the direction of the mobile platform. The gesture 2 makes the mobile platform to move in forward direction, the gesture 3 makes the mobile platform to move in backward direction, gesture 4 makes it turn along left and gesture 5 make it turn along the right direction.

4.6. Visual identification of modes

The three modes i.e. the power OFF mode, Arm -1 mode (right arm mode), Arm -2 mode (left arm mode) and the driving mode can be identified visually with the help of two indicator led in the joystick (Figs. 23–26).

Fig. 23. Power OFF mode.

Fig. 24. Right Arm mode.

Fig. 25. Driving mode.

Fig. 26. Left Arm mode.

5. Proposed algorithm

The total algorithm involved in this work is divided into three sections. They are

- Hub
- Joystick
- Robot

5.1. Hub algorithm

Fig. 27.

5.2. Joystick algorithm

Fig. 28.

5.3. Robot algorithm

Fig. 29.

6. Results

While other works are trying to operate 3 axis robotic arms with more than one MPU [2,5], this work makes it possible to operate a fully functional 6 DOF robotic arm with single MPU. The primary controller of this joystick is designed for right hand use, so it can be operated easily. Hence the controller is hand operated; the environment around the operator doesn't affect the operation of the robot by the user. The other work related to the project discussed above uses cameras [1,3,4] and more than one hand use, which make it more difficult to operate it in different environment. The controller described in this work uses one hand control method (the operator can controller both arms using right controller by shifting modes or he/she can use a left controller to operate the two arms individually) which make the operator to easily operate the robot under any conditions.

Please cite this article as: P. Prakash, C. Dhanasekaran, K. Surya et al., Gesture controlled dual six axis robotic arms with rover using MPU, Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2019.06.702

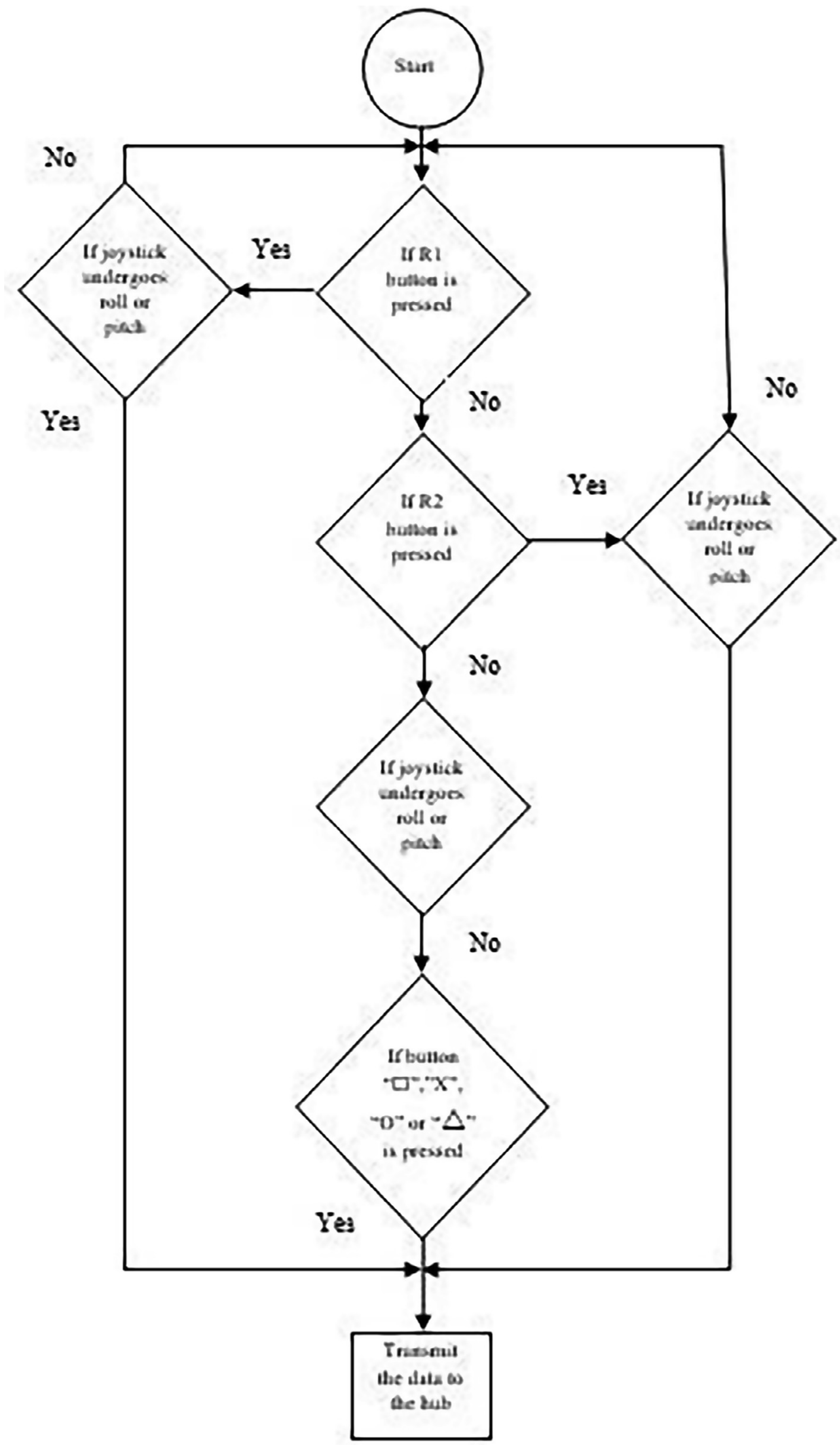

Fig. 27. Joystick algorithm.

The developed robot described in this project with primary joystick (i.e. right hand joystick) is tested with 10 peoples, in which 8 of them easily adapted to the system within few minutes, 2 people take some time to remember the control strategy of the robot (Fig. 30).

The developed robot described in this project with both primary and secondary joystick (i.e. both left and right hand controllers) is tested with another set 10 peoples, in which 9 of them learnt the control strategy easily and felt easy to take over all the operations of the robot. The one person took few minutes to understand the control strategy (Fig. 31).

With the dual arms controlled individually while operating the mobile platform, this robot can be used to perform defence operations in critical areas. The control strategy is simple and the con-

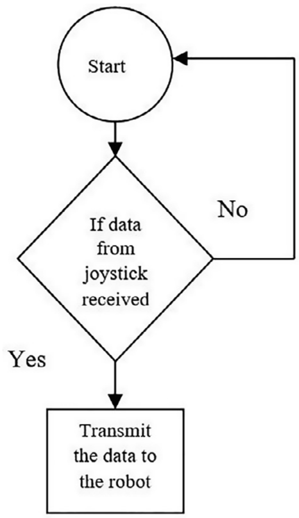

Fig. 28. Hub algorithm.

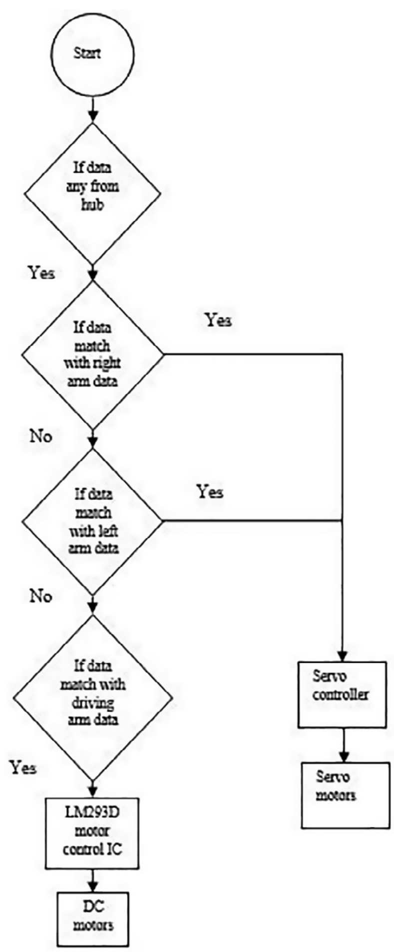

Fig. 29. Robot algorithm.

troller is small in size, which makes it possible to carry around and operate the robot in any area.

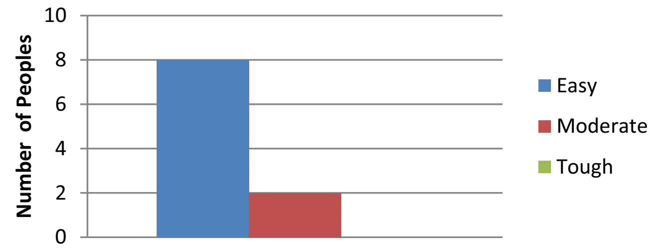

Fig. 30. Right joystick tested with 10 peoples.

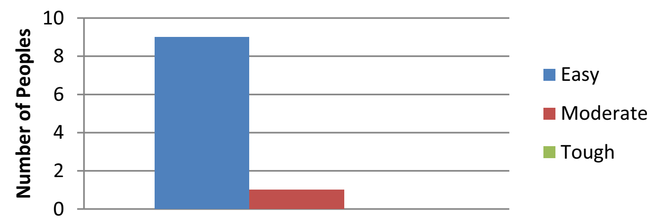

Fig. 31. Right and left joystick tested with 10 peoples.

7. Conclusion

The work described in this paper is developed and tested with two sets of peoples, in which each set has 10 numbers of peoples. The conclusion of the test results shows that most of the people undergone test can easily understand the controller strategy and operate the robot successfully. The results prove that, there are no special skills or trainings are required to operate the described robot. The controller is completely depend on operators hand gestures which concludes the factor the operation of the robot cannot be affected by the operator environment. The robot has two independent 6 DOF arms which replicate the human arm; hence the use of both primary and secondary controller can perform well. The range of operation of the robot can be further extended by adding a secondary hub. The robot will place and activates the secondary hub at the end of the primary hubs receiving range, so that the secondary hub can receive the data from the primary hub and transmit it to the robot.

The developed model propped in this paper can be used for military purpose such as bombs and mine defusing, spying and other repair works in critical areas. It can also be used for space, medical field and research areas. The two motion controlled arms in the rover makes it act efficient in any working condition. The joystick uses motion capture device to detect the hand motion, hence the environment around the operator can't affect the operation of the robot. The range of operation of the developed model is 1 km in open space. Wireless cameras can be used to get live feedback from the robot to accomplish long distance operations. FPV camera with 5.8 GHz, 40 channel video transmitter can be used to transmit video up to 1.5 mile (2.4 km).

Acknowledgement

The authors like to express special thanks of gratitude to VISTAS for funding. Secondly we would also like to thank our parents and friends who helped me a lot in finalizing this project within the limited time frame.

References

[1] Y. Pititeeraphab, P. Choitkunnan, N. Thongpance, K. Kullathum, Ch. Pintavirooj, Robot-arm control system using LEAP motion controller 2016, in: International Conference on Biomedical Engineering (BME-HUST), IEEE, 2016, pp. 109–112.

[2] Pedro Neto, J. Norberto Pires, A. Paulo Moreira, Accelerometer-based control of an industrial robotic arm, in: RO-MAN 2009-The 18th IEEE International Symposium on Robot and Human Interactive Communication, IEEE, 2009, pp. 1192–1197.

[3] Jagdish Lal Raheja, Radhey Shyam, Umesh Kumar, P. Bhanu Prasad, Real-time robotic hand control using hand gestures, in: 2010 Second International Conference on Machine Learning and Computing, IEEE, 2010, pp. 12–16.

[4] Juan Pablo Wachs, Mathias Kölsch, Helman Stern, Yael Edan, Vision-based hand-gesture applications, Commun. ACM 54 (2) (2011) 60–71.

[5] Ariful Islam Bhuyan, Tuton Chandra Mallick, Gyro-accelerometer based control of a robotic arm using AVR microcontroller, in: 2014 9th International Forum on Strategic Technology (IFOST), IEEE, 2014, pp. 409–413.

[6] A. Syed, T.H. Zamrrud, T.M. Agasbal, G. Bheemesh, Flex sensor based robotic arm controller using micro controller, J. Softw. Eng. Appl. 5 (5) (2012) 364.

[7] D. Bassily, C. Georgoulas, J. Guettler, Thomas Linner, T. Bock, Intuitive and adaptive robotic arm manipulation using the leap motion controller, in: ISR/Robotik 2014; 41st International Symposium on Robotics, VDE, 2014, pp. 1–7.

[8] Stefan Waldherr, Roseli Romero, Sebastian Thrun, A gesture based interface for human-robot interaction, Autonomous Robots 9 (2) (2000) 151–173.

[9] Markos Sigalas, Haris Baltzakis, Panos Trahanias, Gesture recognition based on arm tracking for human-robot interaction, in: 2010 IEEE/RSJ International Conference on Intelligent Robots and Systems, IEEE, 2010, pp. 5424–5429.

[10] Kun Qian, Jie Niu, Hong Yang, Developing a gesture based remote human-robot interaction system using Kinect, Int. J. Smart Home 7 (4) (2013) 203–208.

[11] Cynthia Breazeal, Brian Scassellati, Robots that imitate humans, Trends in Cogn. Sci. 6 (11) (2002) 481–487.

[12] Siddharth S. Rautaray, Anupam Agrawal, Vision based hand gesture recognition for human computer interaction: a survey, Artif. Intell. Rev. 43 (1) (2015) 1–54.

[13] Ludovic Brethes, Paulo Menezes, Frédéric Lerasle, J. Hayet, Face tracking and hand gesture recognition for human-robot interaction, in: IEEE International Conference on Robotics and Automation, 2004. Proceedings. ICRA'04. 2004, IEEE, 2004, pp. 1901–1906.

[14] Kai Nickel, Rainer Stiefelhagen, Visual recognition of pointing gestures for human–robot interaction, Image Vis. Comput. 25 (12) (2007) 1875–1884.

[15] Seong-Whan Lee, Automatic gesture recognition for intelligent human-robot interaction, in: 7th International Conference on Automatic Face and Gesture Recognition (FGR06), IEEE, 2006, pp. 645–650.

[16] Ying Wu, Thomas S. Huang, Vision-based gesture recognition: a review, in: International Gesture Workshop, Springer, Berlin, Heidelberg, 1999, pp. 103–115.

[17] Jochen Triesch, Christoph Von Der Malsburg, A gesture interface for human-robot-interaction, in: Proceedings Third IEEE International Conference on Automatic Face and Gesture Recognition, IEEE, 1998, pp. 546–551.

[18] Dennis Perzanowski, Alan C. Schultz, William Adams, Elaine Marsh, Magda Bugajska, Building a multimodal human-robot interface, IEEE Intell. Syst. 16 (1) (2001) 16–21.

Please cite this article as: P. Prakash, C. Dhanasekaran, K. Surya et al., Gesture controlled dual six axis robotic arms with rover using MPU, Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2019.06.702