



# Virtual Reality–Integrated Telepresence Robot for Intelligent Remote Monitoring

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**Abstract:** In the current day and age, telepresence has gained more and more recognition, and individuals cannot be physically present at two or more places simultaneously. Telepresence systems are already being used in surveillance and dangerous places where the lives of individuals are at risk. This project aims to build a gesture-controlled virtual telepresence robot, which can be used in defense, mining, and educational scenarios. The system will include a robot with a camera for real-time video streaming, a VR headset with a smartphone for viewing the video, and gesture-controlled gloves for controlling the robot's movement. A Raspberry Pi will be used for real-time video streaming over Wi-Fi to the smartphone, which will be inserted into the VR headset. The robot will be controlled with the help of hand gestures, which will be detected with the help of an MPU6050 accelerometer connected to the user's glove. The gestures will be detected with the help of Arduino Nano over Bluetooth and processed with the help of an Arduino Uno, which will control the robot with the help of a motor driver. A servo motor will be used to rotate the camera up to 180 degrees.

**Keywords:** virtual telepresence, remote controlled, VR, hand gloves, surveillance.

## I. INTRODUCTION

The telepresence robot is a representation of the next step in digital interactive communication. This device is a step forward in virtual communication. A telepresence robot is a device that allows a user to actively engage in interaction with a particular environment. Even though it is a developing technology, it has already been implemented in the business world and the health industry. In the business world, telepresence robots have greatly contributed to the improvement of the efficiency of virtual meetings. They allow a user to navigate a space remotely. This allows for a better observation of a particular environment and the individuals in it. A gesture control device is incorporated in this project. This is a step forward in telepresence robots. They are designed to reduce the amount of work and increase the speed and accuracy of a particular task. They are non-living entities and can be programmed to react in a particular manner. A Pi camera is connected to a smartphone that is connected to a VR headset. This is because the robots are non-living things, and hence the work done by the robots is based on the program, which is initially kept in the robot or communicated to the robot in some technological way. The live video of the environment in which the robot is kept is obtained through the Pi camera and sent to the smartphone in the VR headset used by the user. The video is sent in the screen facility of the smartphone in order to have a feeling of a virtual environment. The accelerometer and Bluetooth module have been used in order to have a gesture-controlled robot.

## II. LITERATURE REVIEW

Literature review is the survey done on the previous research and the projects carried out. This chapter includes review on 10 different papers published at various journals and conferences. It provides us with a greater knowledge and wider range of exposure in the area of the topic being dealt.

Sunil and others proposed that in today's world telepresence is nothing less than a necessity as a person can't be everywhere and it can be used for variety of reasons including saving lives of people. This can be solved by a robot which can be controlled from a distant location. This paper deals with a new virtual telepresence robot with gesture control which can be used in defence as well as life threatening jobs like mining, for educational purposes. Robots when compared to humans can easily survive the atmosphere which is developed in the field of mining and in defence. In this paper, a method to control a robot from a distant location is discussed. Here the robot is being controlled by hand gestures which in other terms is known as accelerometer and is captured by a camera which gives the live stream video.



The results of the experiments done are really promising. This method is robust and can really be helpful in the field of defence and mining [1].

Lavanya M et al. define the telepresence robot as "a wheeled robot designed to be operated from a distance by a user, equipped with a display and camera to facilitate real-time video streaming of the environment to the user." The system proposed includes a VR headset connected to a smartphone having a dual-screen display to offer an immersive virtual reality experience. It also includes a four-wheeled robot. The robot's movement is controlled by a remote controller. The camera's direction and movement are controlled by the accelerometer and magnetometer sensor data. The sensor data is processed by the microcontroller and embedded systems like Arduino and Raspberry Pi. The captured videos are transmitted in real time from the robot to the smartphone using an IP connection configured by the Raspberry Pi. [2].

NasiruAdamu and others understood that Robot allows a user to have a limited virtual access to a physical environment. The proposed system aims to use the concept of telepresence robots incorporating Virtual Reality to create a VR surveillance robot for the military. The novelty of our robot is that no conventional controllers are used for the motion control rather the user's movement in the physical space itself is mapped to the robot. The robot design is based on an Arduino Mega coupled with motors for driving the wheels. The VR design is based on a Raspberry Pi to which a camera module is connected. The live footage captured by the camera is then streamed wirelessly to an android smartphone running the VR app. The smartphone is placed in a VR headset worn by the user. The main advantage of the proposed system is that the user will not have to depend on an additional controller for controlling the robot [3].

Annica Kristooffersson and associates studied Mobile Robotic Telepresence (MRP) systems, which combine remotely controllable mobile robots with video conferencing technology. These systems are increasingly utilized in office settings, healthcare facilities, and independent living for the elderly. Their main purpose is to improve social interaction. Their paper offers a thorough summary of current MRP systems, application domains, and significant issues noted in earlier studies. Additionally, it highlights design implications to enhance social interaction through MRP technologies, suggests standardized terminology for the field, and discusses future research directions for system development and evaluation [4].

According to Han Sang-Lin and others, consumers are not immediately embracing virtual reality (VR) shopping, despite the fact that it offers modern marketers new opportunities. Through the use of the Technology Acceptance Model (TAM) and consumer flow theory, our research seeks to understand the fundamental elements that promote the adoption of VR technology. In particular, we discover that antecedent factors of technology acceptance, such as playfulness and usefulness, are positively correlated with factors that improve consumer flow, such as telepresence, challenge, body ownership, and control. These factors are then linked to higher intentions to adopt and use VR technology in a consumer setting. We also look into how time distortion and technological readiness affect the relationship between playfulness and telepresence. Participants were asked to wear VR glasses in a real VR supermarket designed specifically for this study in order to gather data. This study makes significant contributions to the literature and has implications for marketing managers by clarifying elements that facilitate consumer adoption of VR technology and highlighting special aspects of VR (such as telepresence and time distortion) [5].

According to Taeyong Kim and others who focused on the use of media theory, the concept of presence should be applicable to all forms of virtual environments including those of traditional media like television and traditional content such as advertising. This study reports the results of an experiment on the effects of the visual angle of the display (sensory saturation) and room illumination (sensory suppression) on the sensation of telepresence during normal television viewing. A self-report measure of presence yielded two factors. Using terminology for the sense of being transported to a mediated environment, we labeled the two factors "arrival," for the feeling of being there in the virtual environment, and "departure," for the feeling of not being there in the in physical environment. It seems that being in the virtual world is not the same as not being in the real one. These two factors have quite different relationships to viewer memory for the experience and to attitude change (i.e., buying intention and confidence in product decision), according to a path analysis. We hypothesize that the departure factor might be a measure of the sense that the medium has vanished and could represent a more profound immersion in the virtual world. The study found no evidence that telepresence was impacted by room illumination or visual angle [6].

Chintapatlasrivarshini and others have used a telepresence surveillance robot as a remote-controlled, wheeled device with a display to enable video streaming which enable the participants to view remote locations, as if they were there. This virtual surveillance robot allows the user to capture the real-time video even when the robot is in a remote location and displays it on the user's virtual reality (VR) headset. This robot is a wheeled, Bluetooth remote-controlled device with a camera to capture real-time video using Raspberry Pi (RPi) in visual form. The Bluetooth remote controller controls the movement and the direction of the Robot via Arduino. The Livestreamed video can be received on any Smartphone device using the specified IP address by Raspberry Pi [7].



Quin Tan et al. discuss that there is a need to recognize that conducting laboratory and field work for distance education is a significant challenge for students, educators, and educational institutions. For this reason, there is an emerging solution for TRESL, which is referred to as the Telepresence Robot Empowered Smart Lab. The paper is based on developing a conceptual model that includes defining the objectives of the proposed system, as well as its architecture and functional modules, which have been designed to enable its functions. The research includes a pilot project, where a telepresence robot is implemented in a simulated smart lab, and then data collection and user analysis. The research findings indicate that online users can easily use the proposed system, and that manual control of the robot increases user engagement and interest in using the remote laboratory. The research is significant as it provides robust evidence that the proposed TRESL system is a promising and innovative solution for enabling remote work for online education, as well as indicating avenues for future research and development. [8].

According to Suraj Kupale et al., the proposed idea for a telepresence robot involves a remotely controlled robot with wheels and a screen and camera for real-time video streaming, allowing users to experience remote environments as if they were physically present at the location. The proposed idea involves a VR headset connected with a dual-screen smartphone for an immersive virtual reality experience and a four-wheeled robot for movement. The movement of the robot can be controlled using a remote controller or a smartphone application, while the movement of the camera can be controlled using an accelerometer and magnetometer. These values are processed using Arduino and Raspberry Pi platforms. The robot with a camera attached is placed at a remote location for real-time video streaming. The video streaming is done by configuring an IP address on the Raspberry Pi connected with the smartphone for displaying the video captured by the camera attached to the robot at the remote location. In addition, the proposed idea allows users not only to view the remote location but also to interact with the remote environment for a better sense of presence. [9].

M. Khalifa et al. describe that the impact of presence on users' attitude and behavior has been well supported by existing literature. However, little is known about the role played by system design factors in the formation of users' sense of presence in computer-mediated environments, especially in the context of virtual communities. In order to fill the existing knowledge gap, the present study aims to investigate the association between key system design factors and users' sense of presence. A multidimensional approach for understanding presence is used for exploring deeper insights into the contribution of various factors for improving user experience. [10].

### III. PROPOSED METHODOLOGY

Our system is built using Arduino and raspberry pi, where Arduino will handle robot and camera movements based on gestures made by user's and raspberry pi will handle camera streaming as shown in FIGURE 1. In our project we have made use of Arduino Uno, Arduino NANO, Raspberry pi3, MPU6050 Triple-axis Accelerometer (Gyroscope), Pi camera, L298N Motor driver, DC Motors, MG995 Servo motor, Bluetooth module, Batteries and Connecting wires. A robot is constructed with Arduino controlling it. A camera is attached to raspberry pi which will take live streaming video and pictures at that instant and then sends it to pi. Robot motors are connected to Arduino Uno through motor driver. A servo motor is used to rotate Pi camera so that we obtain the full view of the environment.

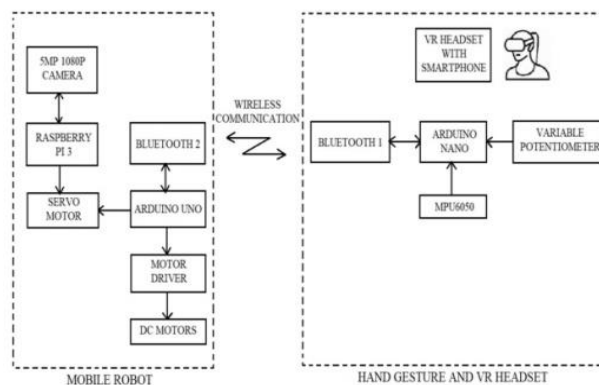


Fig 1. Block Diagram of Mobile Robot with Hand Gesture and VR Headset.

Hand gestures are recognized using Arduino NANO and gyroscope, where the recognized gesture will be sent through Bluetooth module. User wearing a gesture recognition module which is built using NANO will recognize the gesture



based on gyroscope. That data will be sent to Arduino Uno using Bluetooth module. Uno will react to the received data and actuates the motors to rotate in required direction accordingly thereby controlling the robot. Raspberry pi will stream the video in real time which can be viewed using a Virtual Reality headset.

### A. Raspberry pi 3

The Raspberry Pi is a computer that can plug into a computer monitor or TV, and uses a standard keyboard and mouse. It is a capable little computer that allows people of all ages to explore computing, and to learn how to program in languages such as Python. The Clock Speed of Arduino is 16 MHz, whereas the Clock Speed of Raspberry Pi is 1.2 GHz. Raspberry Pi can be used to develop software applications using Python. Raspberry Pi is 40 times faster than Arduino, and with PI, you can send mails, listen to music, play videos, etc. You can also perform internet activities, etc., and it has its own memory, processor, USB ports, Ethernet ports, etc., and it does not require any external hardware for these operations. Raspberry Pi 3 model has the advantage of wireless LAN and Bluetooth, making it the powerful platform for connected designs. There are three main advantages of Raspberry Pi 3 compared to Raspberry Pi 2. It has Bluetooth, Wi-Fi, and it has a more powerful CPU pair too. Here, the rotation of the camera is done by the Raspberry Pi.

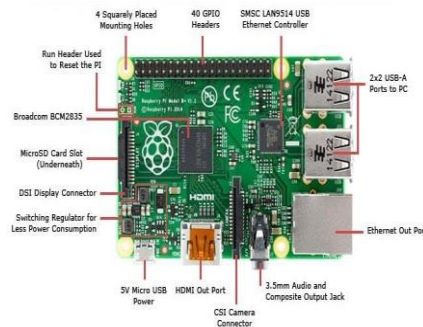


Fig 2. Raspberry Pi 3

### B. MPU-6050 Triple-Axis Accelerometer

Triple-axis gyroscopes are used for measuring angular velocity, and these can be combined with accelerometers, as they can be processed using various sophisticated methods such as sensor fusion. The triple-axis gyroscope is capable of measuring rotation on three axes: X, Y, and Z. The triaxial accelerometer is used for measuring acceleration on three axes. The triaxial accelerometer is composed of three sensors, and these sensors are oriented at right angles to one another. The movement of the robot, such as forward, backward, left, and right, is controlled based on user hand movements using gyroscopes. The MPU-6050, which is a combination of a triple-axis gyroscope and accelerometer, is used for controlling the movement of the robot, as shown in Figure 3.

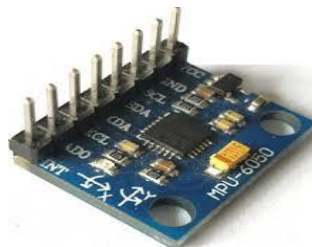


Fig 3. Mpu-6050 Triple-Axis Accelerometer

### C. HC05 Bluetooth Module

The HC-05 Bluetooth Module is a user-friendly Bluetooth Serial Port Protocol (SPP) module. It is designed to create transparent serial communication wirelessly. It is equipped with a fully qualified Bluetooth system with a data rate of up to 3 Mbps. It is also equipped with a complete 2.4 GHz radio transceiver and baseband system integrated into a single chip. It is built using CSR BlueCore 04-External CMOS technology with Adaptive Frequency Hopping (AFH) features. It is compact in size, approximately 12.7 mm × 27 mm. It is equipped with six pins: VCC, GND, TX, RX,



KEY, and LED. By default, the module is configured to work in slave mode. Therefore, it is only able to accept incoming connections. It is not possible for the module to initiate a connection unless it is configured to work in master mode. However, once the connection is established, the module is able to transmit data regardless of the operating modes. Therefore, the simplicity of the module makes it possible for the HC-05 module to be used as a replacement for wired serial communication.



Fig 4. Bluetooth Module Hc05

#### D. Raspberry Pi Camera

The Raspberry Pi camera module has the ability to take high-resolution images and record full HD videos at 1080p resolution and can be controlled programmatically for different applications. In the proposed system, a camera module of 5MP is utilized for capturing live video feed for real-time streaming. The camera module also has an infrared filter, which reduces the sensitivity of the camera to infrared light and provides more natural colors, especially during outdoor photography. However, during photography, especially nature photography, it is recommended to remove the infrared filter, which alters the color of objects such as the sky, plants, and water, providing better results for nature photography. In addition, the camera module without the infrared filter also has the ability for night vision in infrared light conditions. The camera module of Raspberry Pi utilized in the proposed system is shown in Figure 5.



Fig 5. Raspberry Pi Camera

#### E. VR Headset

The use of a VR headset enables a person to access and enjoy virtual reality through images received through a camera. A VR headset replaces a person's natural environment with a virtual reality image, for example, a movie, a game, or a pre-recorded virtual reality environment in which a person can rotate and view different images as they do in the natural world. The use of a VR headset, which in this case refers to goggles that will hold a smartphone, has enabled the use of a variety of VR apps. The purpose of a VR headset is to enable the viewer of an image to have an experience that feels so natural. Virtual reality headsets and viewers have been designed for use with smartphones. These devices are different from other devices in that they are essentially enclosures that can hold a smartphone. The images in a VR environment are viewed on a smartphone screen through a lens. The VR Headset is as shown in FIGURE 6.



Fig 6. VR Headset

#### F. MG995 Servo Motor

The MG995 Servo Motor is a standard servo motor of high torque. It is commonly used for various applications, including robotic arms, heads, etc. It is equipped with metal gear for strength. It also has a standard 3-pin configuration. A servo motor is a device designed to rotate the motor shaft accurately to a particular angle. It is enabled by the feedback mechanism inside the servo motor. A servo motor is equipped with an internal feedback system that



continuously monitors the position of the shaft. It is useful for applications requiring the rotation of the motor shaft to a precise angle. The MG995 servo motor is of high torque and is compact and lightweight. It is useful for various applications, including robotics, R/C cars, toy cars, etc. It is also useful for applications involving the use of model airplanes. It is useful due to its accuracy. It is useful for applications requiring accurate movement. It is shown in Figure 7.



Fig 7. Mg995 Servo Motor

G. Software Requirements

The software used for programming the system is the Arduino Integrated Development Environment and PyCharm. The Arduino IDE supplies a software library from the wiring project, which provides many common input and output procedures. In our model we use embedded C language which we run in Arduino IDE platform. The code is written to move the robot across different directions such as Right, left, forward and backward. Python defines an in-built module platform that provides system information. The Platform module is used to retrieve as much possible information about the platform on which the program is being currently executed. One such is Pycharm. The PyCharm editor is the main part of the IDE that you use to create, read and modify code. The scrollbar shows errors and warnings in the current file. Python 3 is a newer version of the Python programming language which was released in December 2008. This version was mainly released to fix problems that exist in Python 2. The nature of these changes is such that Python 3 was incompatible with Python 2. Here we use Python 3 code to access Raspberry pi which has control over the camera.

IV. SYSTEM IMPLEMENTATION

It includes the hardware and software implementation in the system. It also includes the flowchart which describes the flow of working of the Hand gesture controller.

A. Hardware Implementation

The implementation of the hardware design, including the circuit diagram of the hand gesture controller and the robot module, is shown in Figures 8 and 9. In the hand gesture controller circuit diagram (Figure 13), the serial data pin of the MPU-6050 module is connected to the A4 analog I/O pin of the Arduino Nano, while the serial clock pin of the MPU-6050 module is connected to the A5 analog I/O pin of the Arduino Nano. In addition, a 10kΩ variable potentiometer is connected to the A0 analog pin of the Arduino Nano. In terms of wireless communication, the transmitter pin of Bluetooth Module 1 is connected to the receiver pin of the microcontroller, while the receiver pin of Bluetooth Module 1 is connected to the transmitter pin of the microcontroller. The processed information from the gesture controller will then be transmitted wirelessly by Bluetooth Module 1 and received by Bluetooth Module 2 integrated into the robot module.

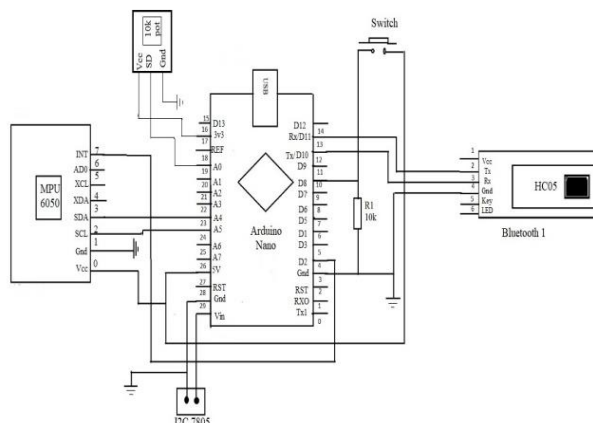


Fig 8. Circuit Diagram Of hand Gesture Controller



In this system, serial communication is achieved between two Bluetooth modules based on a master-slave principle. In this case, the Bluetooth module connected to the hand gesture controller acts as the master, whereas the Bluetooth module connected to the robot acts as the slave. In the robot module circuit (Figure 9), the transmitter (TX) pin of the Bluetooth module is connected to the receiver (RX) pin of the Arduino Uno. Similarly, the receiver (RX) pin of the Bluetooth module is connected to the transmitter (TX) pin of the Arduino Uno. The motor control system uses an L298N Motor Driver. In this case, input pins 1, 2, 3, and 4 of the L298N Motor Driver are connected to D11, D10, D10, and D9 digital I/O pins of the Arduino Uno, respectively. In addition, output pins 1 and 4 are connected to DC Motor 1, whereas output pins 2 and 3 are connected to DC Motor 2. This enables both motors to operate in both forward and backward directions. The MG995 Servo Motor is connected to D6 digital I/O pin of the Arduino Uno to enhance the robot's functionality.

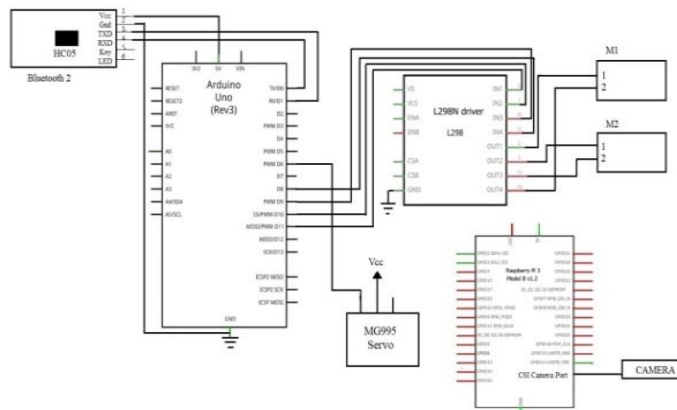


Fig 9. Circuit Diagram of Mobile Robot Module

The Raspberry pi is mounted on the robot module, the pi camera is connected to CSI Camera port of the raspberry pi and the camera is mounted on MG995 Servo motor. Here, based on the instructions obtained from hand gesture controller via Bluetooth module 1 to Arduino Uno through Bluetooth module 2 the DC motors are operated with the help of motor driver and the camera rotation is controlled by servo motor hence the robot operates accordingly.

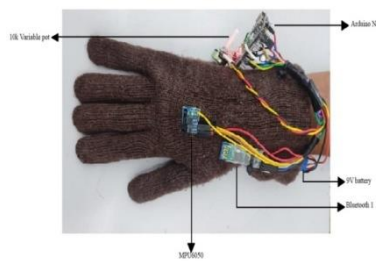
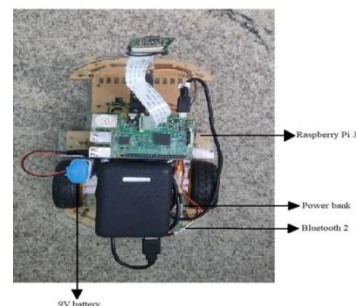
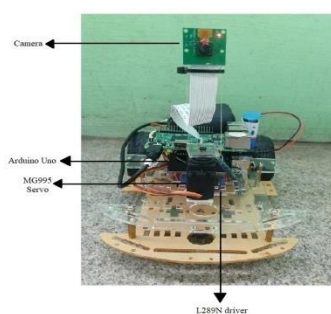


Fig 10. Hand Gesture Controller

The Hand gesture controller contains MPU6050 Triple-axis Accelerometer (gyroscope), Arduino NANO, Bluetooth module-1, 10k Variable pot and 9V battery as shown in FIGURE 10. This controls the movement of mobile robot in different directions such as Forward, backward, Left and Right based on the alignment of gyroscope.





The Front view of the Mobile robot module is as shown in FIGURE 11(a) which shows Camera, Arduino Uno, MG995 Servo motor and L298N driver. The Top view of the Mobile robot module is as shown in FIGURE 11(b) which shows Raspberry Pi 3, Power bank, Bluetooth module-2 and 9V battery.



Fig 12 (a) Left Side & (b) Right Side View Of Mobile Robot Module

The Left side view of the mobile robot module is shown in FIGURE 12 (a) and the Right side view of the mobile robot module is shown in FIGURE 12(b).

B. SOFTWARE IMPLEMENTATION

The Software platform used for the successful implementation of the proposed system are Arduino IDE and Python 3. The Arduino IDE is used for coding to Arduino Uno and Nano to control the movement of robot module in different directions whereas Python 3 software is used to code for Raspberry pi to control the surveillance of the camera.

C. Programming using Python

Enable the Raspberry Pi Camera Module

First the Raspberry pi camera software is enabled in Raspberry pi in order to use it. For the desktop environment, go to Raspberry Pi Configuration window under the Preferences menu, open the Interfaces tab and enable the Camera as shown in FIGURE 13.

Fig 11 (a) Front View & (b) Top View Of Mobile robot Module

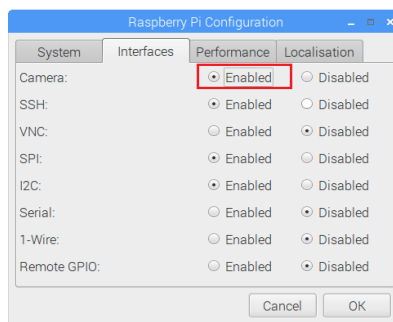


Fig 13. Raspberry Pi configuration Window

Finding Raspberry Pi IP Address

To access the video streaming web server, we need to know the IP address of the Raspberry pi we have used. For that we need to use the following command: `pi@raspberrypi:~$ ifconfig` Then we will get a bunch of information, including our Raspberry pi IP address. In our case, the IP address is 192.168.6.18.

Accessing the video streaming

Once the script compiled is running, we can access the video streaming web server at: `http://<Your_Pi_IP_Address>:8000`. In our case the address is: `http://192.168.6.18:8000`



V. FLOWCHART

The series of flow in which the hand gesture controlling process is carried out is as depicted in the Fig.4.8. Initially, when the process starts, all the control boards such as Raspberry pi, Arduino Uno and Arduino Nano and peripherals such as MPU6050 gyro sensor and Bluetooth modules will be initiated. After the initialization the Gyro sensor starts sending the data to Arduino Nano. Once, the data is acquired it transmits the data to Arduino Uno of robot module via Bluetooth module. We have initialized to variables named as V and U as shown in Fig.4.8. For If condition, if the value of V is within the range as initialized then the robot moves in forward direction if not it checks for the next condition.

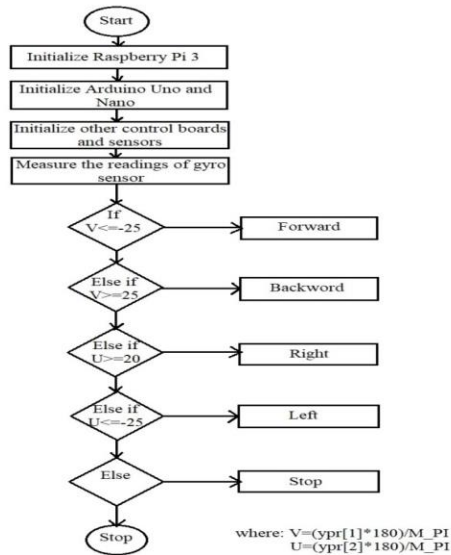


Fig 14. Flowchart of Hand Gesture controlling Process

Now for First Else if condition, if the value of V is within the range as initialized then the robot moves in backward direction if not it checks for the next condition. Now for Second Else if condition, if the value of U is within the range as initialized then the robot turns right if not it checks for the next condition. Now for Third Else if condition, if the value of U is within the range as initialized then the robot turns Left if not it checks for the next condition. If none of the above condition is satisfied, then the Else condition is considered and the robot stops. This process is depicted in the flowchart shown in FIGURE 14.

VI. RESULTS

The Robot is programmed to move in different directions like Left, Right, Forward or Backward based on the user’s hand movement using Gyroscope. The captured images in the virtual reality headset are displayed through Wi-Fi as live streaming for Surveillance. The movement of camera rotation about 180 degree using servo motor can be achieved.

Case-1: Movement in Forward Direction



(a)



(b)

Fig 15. (a) Hand Gesture and (b) Movement of Robot In Forward Direction

The FIGURE 15(a) shows user’s hand gesture for the movement of mobile robot in forward direction and



FIGURE 15(b) shows mobile robot module moving in forward direction.

	X	Y	Z
ypr	116.19	-34.60	-25.98
ypr	116.26	-34.58	-25.95
ypr	116.35	-34.55	-25.90
ypr	116.43	-34.47	-25.85
ypr	116.54	-34.39	-25.79
ypr	116.65	-34.33	-25.77
ypr	116.77	-34.29	-25.72
ypr	116.88	-34.23	-25.66
ypr	116.96	-34.19	-25.64
ypr	117.02	-34.17	-25.63
ypr	117.06	-34.13	-25.67
ypr	117.09	-34.11	-25.72
ypr	117.11	-34.08	-25.76

Fig 16. Screenshot Of gyro Sensor output For forward Movement

The screenshot of the gyro sensor output for forward movement of mobile robot is as shown in FIGURE 16. The values of x, y and z-axis coordinates for the alignment of the gyro sensor for robot movement in forward direction is recorded.

Case-2: Movement in Backward Direction



(a)



(b)

Fig 17 (a) Hand Gesture and (b) Movement Of Robot In Backward Direction

The FIGURE 17 (a) shows user’s hand gesture for the movement of mobile robot in backward direction and FIGURE 17(b) shows mobile robot module moving in backward direction.

	X	Y	Z
ypr	46.55	49.63	13.07
ypr	46.50	49.63	13.03
ypr	46.44	49.62	12.98
ypr	46.37	49.62	12.94
ypr	46.30	49.61	12.90
ypr	46.25	49.62	12.88
ypr	46.21	49.64	12.89
ypr	46.17	49.66	12.89
ypr	46.13	49.70	12.90
ypr	46.10	49.72	12.89
ypr	46.05	49.74	12.89
ypr	46.01	49.74	12.90
ypr	45.95	49.73	12.92
ypr	45.90	49.72	12.93
ypr	45.85	49.70	12.93

Figure 18.Screenshot of Gyro Sensor Output for Backward Movement

The screenshot of the gyro sensor output for backward movement of mobile robot is as shown in FIGURE 18. The values of x, y and z-axis coordinates for the alignment of the gyro sensor for robot movement in backward direction is recorded.



Case-3: Movement for Turning Left



Fig19. (a) Hand Gesture and (b) Movement Of Robot In Left Direction

The Figure 19(a) shows user’s hand gesture for turning of mobile robot in left direction and Figure 19(b) shows mobile robot module turning left.

	X	Y	Z
ypr	47.87	15.71	-57.62
ypr	47.83	15.69	-57.68
ypr	47.79	15.67	-57.73
ypr	47.78	15.66	-57.74
ypr	47.77	15.64	-57.74
ypr	47.78	15.62	-57.71
ypr	47.78	15.59	-57.67
ypr	47.80	15.59	-57.61
ypr	47.82	15.60	-57.56
ypr	47.84	15.64	-57.53
ypr	47.85	15.67	-57.51
ypr	47.85	15.69	-57.51
ypr	47.82	15.71	-57.53
ypr	47.80	15.69	-57.54

Figure 20.Screenshot of Gyro Sensor Output for Left Movement

The screenshot of the gyro sensor output for left turn of mobile robot is as shown in FIGURE 20. The values of x, y and z-axis coordinates for the alignment of the gyro sensor for robot left turn is recorded.

Case-4: Movement for Turning Right



Fig 21. (a) Hand Gesture and (b) Movement of Robot In Right Direction

The Figure 21(a) shows user’s hand gesture for turning of mobile robot in right direction and Figure 21 (b) shows mobile robot module turning right.

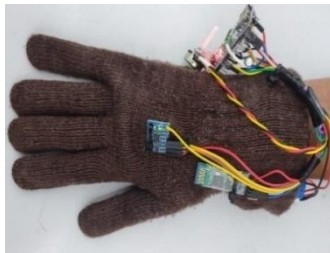


	X	Y	Z
ypr	15.54	4.83	54.16
ypr	15.65	4.85	54.12
ypr	15.78	4.87	54.07
ypr	15.92	4.90	54.00
ypr	16.06	4.95	53.95
ypr	16.16	5.00	53.97
ypr	16.25	5.06	54.00
ypr	16.34	5.11	54.03
ypr	16.41	5.11	54.05
ypr	16.42	5.09	54.06
ypr	16.38	5.06	54.06
ypr	16.30	5.03	54.07
ypr	16.21	5.00	54.06

Fig22. Screenshot of Gyro Sensor Output for Right Movement

The screenshot of the gyro sensor output for right turn of mobile robot is as shown in FIGURE 22. The values of x, y and z-axis coordinates for the alignment of the gyro sensor for robot right turn is recorded.

Case-5: For Stop Condition



(a)



(b)

Figure 23 (A)Hand Gesture And (B) Movement Of Robot In Stop Condition

The Figure 23.a) shows user’s hand gesture for mobile robot stopping condition and FIGURE 23(b).shows mobile robot module in stop condition.

	X	Y	Z
ypr	66.62	-3.14	-22.03
ypr	66.62	-3.13	-22.02
ypr	66.62	-3.14	-22.03
ypr	66.62	-3.14	-22.03
ypr	66.62	-3.14	-22.03
ypr	66.62	-3.14	-22.03
ypr	66.62	-3.14	-22.03
ypr	66.62	-3.14	-22.03
ypr	66.62	-3.14	-22.03
ypr	66.62	-3.14	-22.03
ypr	66.62	-3.14	-22.03
ypr	66.62	-3.14	-22.03
ypr	66.62	-3.15	-22.03
ypr	66.62	-3.15	-22.03

Fig 24. Screenshot Of Gyro Sensor Output For Stop Condition

The screenshot of the gyro sensor output for stopping condition of mobile robot is as shown in FIGURE 24. The values of x, y and z-axis coordinates for the alignment of the gyro sensor for robot stopping condition is recorded.

Working of mobile robot module



(a)



(b)

Figure 25 (a) User Controlling Mobile Robot And (b) Screenshot Of Picture captured By Pi Camera on Smartphone

The Figure 25(a) shows the user controlling the mobile robot with the help of hand gloves having gesture controller and wearing the virtual reality headset through which live streaming of pictures captured by the pi camera is viewed through smartphone. FIGURE 25(b) shows the screenshot of the picture captured by the pi camera on the smartphone.

## VII. CONCLUSION

The mobile robot is controlled to move in different directions such as Left, Right, Forward and Backward based on the user's hand movement using Gyroscope which is present on user's hand gloves. The captured images are displayed on the user's Virtual Reality (VR) headset with smartphone through Wi-Fi as live streaming for monitoring the robot surrounding. The camera rotation of up to 180 degrees is achieved with the help of Servo motor.

## VIII. FUTURE SCOPE

The project if developed on a higher end, has a huge scope in the area of defence and mining for surveillance and monitoring. The system can be used as an alternative device which replaces the person to monitor the remote locations. The system can prove to be very efficient and has a huge scope if implemented on higher end. The further enhancement includes the incorporation of a high resolution camera for the live video streaming of the happenings, using sensors with high range of distance for communication between user and the mobile robot and use of high quality virtual reality headsets with inbuilt dual screen.

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