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VIRTUAL REALITY ROBOT WITH 3D VISION

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ABSTRACT

This paper gives us an idea about Virtual reality robot with 3d vision is a set of technologies to enable users to be "present remotely these technologies allow users to be present and to interact with an environment from a place (tele robotics). This paper deals with a very new virtual telepresence robot with added feature that is head movement control that can be used in defense as well as for educational purposes, life threatening jobs like mining. Here we introduce a virtual reality robot with 3d vision, a robot for various applications. As well as in the industry and corporations, telepresence is becoming common in the field of social interactions, for example in business meetings. The robot with a camera is placed in a location to capture the environment in visual form. The captured visuals are displayed on the user's virtual reality (VR) headset. We try to add a special feature which allows the camera to move in the direction of the user's head movements. This gives the user a real-time experience as if he is present where the robot is located. Also, the motion of this robot can be controlled by the user. Our project has a wide range of applications. It can be used extensively in remote location monitoring, healthcare services, as baby monitors and in surveillance and monitoring for security purposes. This is an immense aid to view remote locations and to view the places where mankind cannot sustain.

Keywords*: Tele presence, tele robotics, social interaction, head movements, remote location monitoring.*

1. INTRODUCTION

The main objective of making this project is to provide 3d immersive view to the user hence the user will feel he is present there itself at the distant location. From time immemorial, people faced a lot of limitations without technology. But now as time has passed, people are unable to live without technology. The evolution of mechanical computers to portable tablets and mobile phone has advanced the human race to a next higher level. The world we live in now is one that provides the required entity at just one click. It is also to be noted that the development in science and technology has introduced the concept of virtual reality and robotics.

The term virtual means near and reality is what we experience as human beings. Hence 'virtual reality' means 'near reality'. Robots have increased widely in today's world. In almost all the industries the concept of robotics is used. Robots are also user friendly. Like all real world applications robots have their own disadvantages. Robot needs a supply of power. The robot used in this project uses rechargeable battery. Telepresence is the use of virtual reality technology, especially for remote control of machinery or for apparent participation in distant events. Virtual telepresence robot allows the user to experience virtual reality even when the robot is in a remote location. A person using virtual reality equipment is typically able to "look around" the artificial world, move about in it and interact with features or items that are depicted. They also enable much more interactivity than regular video conferencing.

In a distance education class, for example, a virtual reality robot can move around the room and interact face-to-face with individual students, just as an on-premises instructor might. Virtual realities artificially create sensory experiences, which can include sight, touch, hearing, and, less commonly, smell. Modern-era virtual realities are displayed either on a computer monitor, a projector screen, or with a virtual reality headset. Virtual reality robots can enable remote tour guides, administrative assistants, home visitors, night watchmen and factory inspectors, among many other possibilities. There are many research articles emphasizing the importance of VR application at the remote control. An approach to designing a Virtual Robot for control system design is presented in, robotic Simulation Environment is introduced for testing and visualization of robotic algorithms, but the testing on a real

robot is much longer and tedious process. In contrast to direct interfaces, the virtual reality provides an external perspective which allows the operator to drive/pilot the vehicle from the outside.

2. PROBLEM STATEMENT

Head movement is frequently associated with human motion navigation, and an indispensable aspect of how humans interact with the surrounding environment. In spite of that, the incorporation of head motion and navigation is more often used in the VR (Virtual Reality) environment than the physical environment. We present a very cost-efficient futuristic technology called Virtual Tele-presence Robot. The technology available in market is too costly that common man cannot afford it. The Virtual Tele-presence system is the technology which is very useful. The aim is to provide cost efficient virtual telepresence system for various applications. The components used are raspberry pi cheap credit size computer with video streaming server. It gives 3Dimensional immersive view. By using VR and simple smart phone we can achieve the same 3D effect.

3. OBJECTIVES

Objective 1:

To control the chassis wheels to help the movement of the robot.

Methodology –

1. The navigation circuit controls movement of the robot.
2. Directional command is processed by Raspberry Pi and node MCU and then fed to motor driver.
3. Motor driver operates the DC geared motors instantaneously.

Objective 2:

To align camera tilt movements according to user's head movement.

Methodology –

1. Wireless app is used to process the user's head movements and accordingly align the camera.
2. This app reads accelerometer and magnetometer values of the smartphone placed in the VR headset.
3. The app sends real time signals to the servo motors which in turn move the camera.

Objective 3:

To provide a 3D visual experience to the user by transmitting real time video and audio information

Methodology –

1. Raspberry pi helps obtain a real time experience through live streaming.
2. The camera module is connected to the Raspberry pi. The real time casting of captured video and audio is done through the app.
3. The software co-operates to live streaming.

4. LITERATURE SURVEY

The overall system of the Virtual Reality Telepresence robot can be split up into VR section, robotics section and user section [7].The 1st stage of project hardware is the power supply. Rechargeable batteries are used in the power supply in order to store the power. This is charged up by connecting to a 12V charger. The navigation circuit is the one which controls the movement of the robot. The directional data is sent to the navigation circuit. It is processed by the International Journal of Innovative and Emerging Research in Engineering Volume 4, Issue 2, 2017 56 Arduino and then provided to the driver IC which drives the gear motor in the required direction. This operation can be controlled by transfer of data through Wi-Fi or Bluetooth or RF modules as transmitter and receiver. The casing to hold the gear motors, servo motors, camera and Raspberry Pi was made intact. The next main procedure is the setting up of the Raspberry Pi. The initial configurations are done. The board is connected to the Wi-Fi. An IP address is programmed and setup which links to the Raspberry Pi [5] [6] [9]. The video that is captured by the camera is sent over to the Wi-Fi modem. The modem creates a LAN where in both the smartphone and the Raspberry Pi is connected. It is through this LAN that the data (head movement and video) is shared. This transmitted output can be viewed by connecting the smartphone or the laptop to the same Wi-Fi connection and IP address [3]. This transmitted output is viewed in a smartphone placed in the VR headset. The smartphone is switched to dual screen mode for this purpose. The project also has the feature

of letting the user experience virtual reality by swinging the VR headset. The smartphone reads the accelerometer and magnetometer data of the direction in which the user had turned. This data is sent to the modem over Wi-Fi and to the Raspberry Pi board which in turn provides these values as input to the servo motor. There are two servo motors which are used to move the camera. One for the vertical and other for the horizontal movement [1]. Raspberry pi is the brain of the system [10].

The idea behind this project is taken from ref. paper [1]. This paper explains the working of the robot and capturing of the visuals. Ref. paper [2] talks about Raspberry Pi and its architecture including both hardware and software. The ref. paper [3] [13] gives us a highlight of connecting and controlling motors to the Raspberry Pi. Ref paper [4] talks about Automatic Photography and the communication between the camera module and Raspberry Pi. Ref. paper [5] [13] [8] tells about robotic arm controlled by Raspberry Pi and android application software using Wi-Fi protocol. It also tells about how to configure Wi-Fi and interfacing servo motors with Raspberry Pi. It explains about how to send data from android application to Raspberry Pi. In the case of Ref. paper [1] the mini rover camera is stationary. As the rover moves the camera moves along. Here the visual received is the one that is directly in front of it. In the proposed system we have the facility to rotate the camera according to our head movement. The mini rover gives a normal display. Whereas in the proposed system we get a virtual reality effect. In an ideal case of teleoperation, operators should be provided an immersive first-person perspective of a robot with minimum delay of the information they are to be provided. However, regular remote presence robots and consumer telepresence robots project their camera vision through a video feed on a two dimensional screen. As depth perception is essential in most operations, the lack of a stereoscopic display will hamper a robot operator's judgment about distance, when in turn might lead to unwanted collisions due to misestimating of the surrounding [9] [2] [7]. Here the robot is continuously controlled by head movement which in other terms is known as accelerometer and is captured by a camera which gives the user real time experience as if he/she present where virtual telepresence robot is located that is live stream video. The results of the experiments is we can control the robot via head movement. It is helpful in the field of defense and mining [10].

The raspberry Pi on the robot is configured to a Wi-Fi access point; we can connect to the robot with multiple devices. The PC is the remote controlling machine. It sends the connected keyboard command to the robot via sockets by a python program. Separate raspberry pi is used for the movement control from the PC keyboard, and for the head tracking [2]. Another socket program for the head movement is developed. In this program socket from wireless IMU android app on raspberry pi is received and it gets the mapping to servo positions. In the program user can limit the servo movement to the physical limits of the mechanic. For the video stream UV4L streamer solution is used. User can connect to the stream with browsers, so it's really universal. In the current experimental setup 640x360 videos is streamed. User can connect to this stream via mobile [5]. In contrast to direct interfaces, the virtual reality provides an external perspective which allows the operator to drive/pilot the vehicle from the outside [8].

Here RPI camera will be placed on the robot for capture the image or video and send it back to the data to the user on his smart phone or display [10]. Tele-presence requires that the users' senses be provided with such stimuli as to give the feeling of being in that other location. Additionally, users may be given the ability to affect the remote location. In this case, the user's position, movements, actions, voice, etc. may be sensed, transmitted and duplicated in the remote location to bring about this effect. Therefore information may be travelling in both directions between the user and the remote location [11]. Separate raspberry pi is used for the movement control from the PC keyboard, and for the head tracking. Another socket program for the head movement is developed. In this program socket from wireless IMU android app on raspberry pi is received and get and mapping this to servo positions. In the program user can limit the servo movement to the physical limits of the mechanic [11] [9]. Telepresence tele-robot system can be understood by breaking up the words i.e. telepresence and tele-robot [1] [3] [8] [6] [12]. Telepresence has been defined as the human experience of being present at a live location away from location where he is being present. Someone using this telepresence system would be able to act and receive stimuli in similar way as though he is present in that remote location. And hence it would help users to be part in interactive group activities from a remote location and thus this system has a wide range of applications [2]. Tele-robotics is defined as the area of robotics that is concerned with the control of the autonomous robots from a distant location. It is mainly controlled using the wireless communication networks like WLAN, Bluetooth, Wi-Fi, cellphone network and similar other things) or using wired connections. It is basically the composition of the subfields, teleoperation and telepresence [12].

5. HARDWARE

Components:

Raspberry Pi 3 Model B+ –

The Raspberry Pi is a credit card-sized computer with an ARM processor that can run Linux. This item is the Raspberry Pi 3 Model B+, which has 1 GB of RAM, dual-band Wi-Fi, Bluetooth 4.2, Bluetooth Low Energy (BLE), an Ethernet port, HDMI output, audio output, RCA composite video output (through the 3.5 mm jack), four USB ports, and 0.1″-spaced pins that provide access to general purpose inputs and outputs (GPIO). The Raspberry Pi requires a micro SD card with an operating system on it (not included).

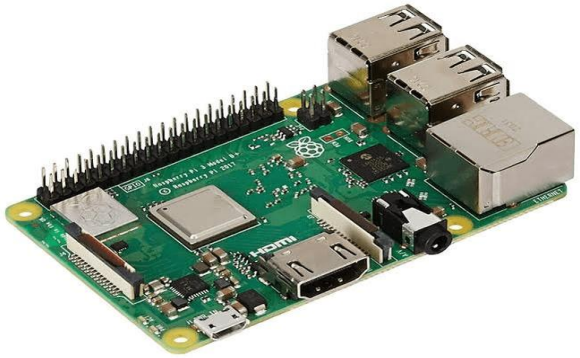
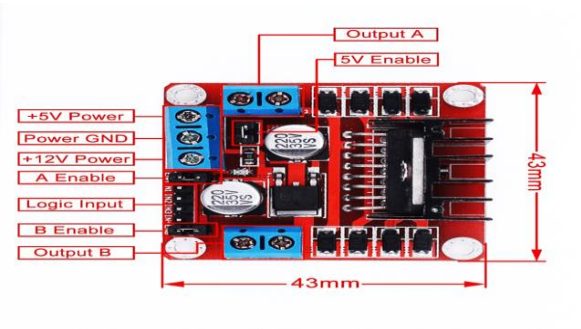


Fig. 1: Raspberry pi 3B+



Raspberry pi Camera –

The Raspberry Pi camera module v1.3 is an official product of the Raspberry Pi foundation. This means it has software and hardware support from the original developers of the credit-card sized computer itself. It packs a 5-megapixel sensor that supports 1080p30, 720p60, and VGA90 video modes, as well as stills capture.

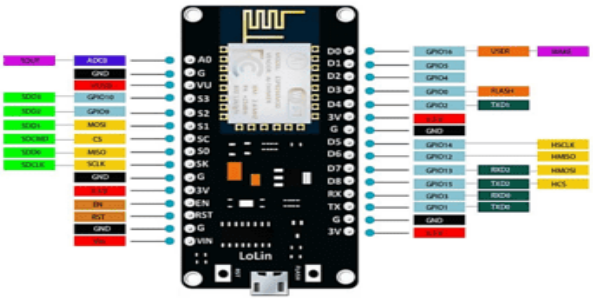


Fig. 3: Node MCU ESP 8266

Node MCU ESP 8266 –

The Node MCU (***N***ode ***M***icro ***C***ontroller ***U***nit) is an open-source software and hardware development environment built around an inexpensive System-on-a-Chip (SoC) called the ESP8266. The ESP8266, designed and manufactured by Espressif Systems, contains the crucial elements of a computer: CPU, RAM, networking (Wi-Fi), and even a modern operating system and SDK.

L298N motor driver –

The L298N Motor Driver module consists of an L298 Motor Driver IC, 78M05 Voltage Regulator, resistors, capacitor, Power LED, 5V jumper in an integrated circuit. 78M05 Voltage regulator will be enabled only when the jumper is placed. When the power supply is less than or equal to 12V, then the internal circuitry will be powered by the voltage regulator and the 5V pin can be used as an output pin to power the microcontroller. The jumper should not be placed when the power supply is greater than 12V and separate 5V should be given through 5V terminal to power the internal circuitry.

Servo motors –

The Servo motors used in this project operates from 4.8V to 6.5V, the higher the voltage higher the torque we can achieve, but most commonly they are operated at +5V. Almost all hobby servo motors can

rotate only from 0° to 180° due to their gear arrangement so make sure you project can live with the half circle if no, you can prefer for a 0° to 360° motor or modify the motor to make a full circle.

DC Motors –

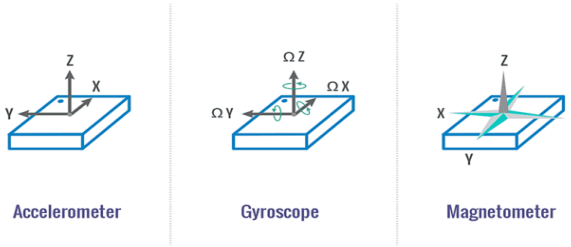
When a current pass through the coil wound around a soft iron core situated inside an external magnetic field, the side of the positive pole is acted upon by an upwards force, while the other side is acted upon by a downward force. According to Fleming's left hand rule, the forces cause a turning effect on the coil, making it rotate. To make the motor rotate in a constant direction, "direct current" commutators make the current reverse in direction every half a cycle (in a two pole motor) thus causing the motor to continue to rotate in the same direction.

IMU Sensors –

Accelerometer: It measures linear acceleration (change of velocity) across a single axis. Integrating acceleration once reveals an estimate for velocity, and integrating again gives you an estimate for position.

Gyroscope: Gyroscopes, however, measure angular velocity about three axes: pitch (x axis), roll (y axis) and yaw (z axis). When integrated with sensor fusion software, a gyro can be used to determine an object's orientation within 3D space.

Magnetometer: A magnetometer, as the name suggests, measures magnetic fields. It can detect fluctuations in Earth's magnetic field, by measuring the air's magnetic flux density at the sensor's point in space.



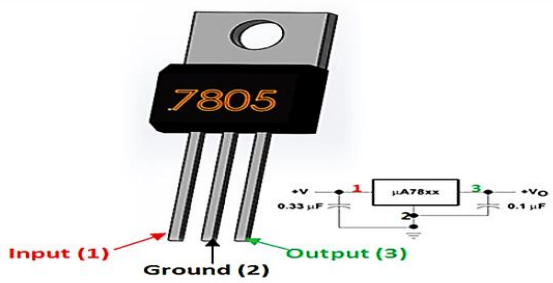
output voltage. The output current of this IC can go up to 1.5A.

Robot Chassis –

4-Wheel Robot Chassis Kit, an easy to assemble and use robot chassis platform. The Chassis kit provides you with everything you need to give your robot a fast four wheel drive platform with plenty of room for expansion to add various sensors and controllers. Just add your electronics - Arduino/Raspberry Pi and Motor Driver and you can start programming your robot. It offers a large space with predrilled holes for mounting sensors and electronics as per your requirement. This robot chassis lets you get your mechanical platform ready in minutes and quick start your robot building process.

Voltage regulator –

In our case the 7805 IC is an iconic regulator IC that finds its application in most of the projects. The name 7805 signifies two meaning, "78" means that it is a positive voltage regulator and "05" means that it provides 5V as output. So our 7805 will provide a +5V



VR headset –

A virtual reality headset is a head-mounted device that provides virtual reality for the wearer. Virtual reality (VR) headsets are widely used with video games but they are also used in other applications, including simulators and trainers. They comprise a stereoscopic head-mounted display (providing separate images for each eye), stereo sound, and head motion tracking sensors (which may include gyroscopes, accelerometers, magnetometers, structured light systems etc.). Some VR headsets also have eye tracking sensors and gaming controllers.

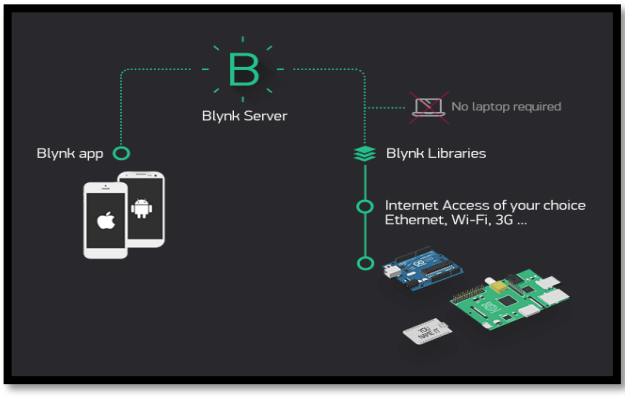
6. SOFTWARE

BLYNK:

Blynk is a new platform that allows you to quickly build interfaces for controlling and monitoring your hardware projects from your IOS and Android device. After downloading the Blynk app, you can create a project dashboard and arrange buttons, sliders, graphs, and other widgets onto the screen. Using the widgets, you can turn pins on and off or display data from sensors. Whatever your project is, there are likely hundreds of tutorials that make the hardware part pretty easy, but building the software interface is still difficult. With Blynk, though, the software side is even easier than the hardware. Blynk is perfect for interfacing with simple projects like monitoring the temperature of your fish tank or turning lights on and off remotely.

Currently, Blynk supports most Arduino boards, Raspberry Pi models, the ESP8266, Particle Core, and a handful of other common microcontrollers and single-board computers, and more are being added over time. Arduino Wi-Fi and Ethernet shields are supported, though you can also control devices plugged into a computer's USB port as well.

There are three major components in the platform –



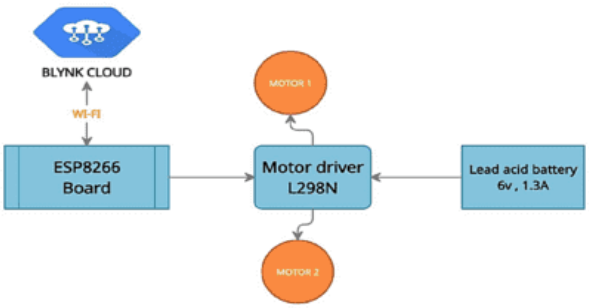
Blynk App: allows to you create amazing interfaces for your projects using various widgets we provide.

Blynk Server: responsible for all the communications between the smartphone and hardware. You can use our Blynk Cloud or run your private Blynk server locally. Its open-source, could easily handle thousands of devices and can even be launched on a Raspberry Pi.

Blynk Libraries: for all the popular hardware platforms - enable communication with the server and process all the incoming and out coming commands.

Raspberry Pi OS:

Raspberry Pi OS is highly optimized for the Raspberry Pi line of compact single-board computers with ARM CPUs. It runs on every Raspberry Pi except the Pico microcontroller. Raspberry Pi OS uses a modified LXDE as its desktop environment with the Open box stacking window manager, along with a unique theme. The distribution is shipped with a copy of the algebra program Wolfram Mathematica and a version of Minecraft called Minecraft: Pi Edition, as well as a lightweight version of the Chromium web browser.



PCManFM is a file browser allowing quick access to all areas of the computer, and was redesigned in the first Raspberry Pi OS Buster release (2019-06-20). Raspberry Pi OS originally used **Epiphany** as the web browser, but switched to **Chromium** with the launch of its redesigned desktop. Raspberry Pi OS comes with many beginner IDEs, such as Thonny Python IDE, Mu Editor, and Greenfoot. It also ships with educational software like Scratch and Bookshelf.

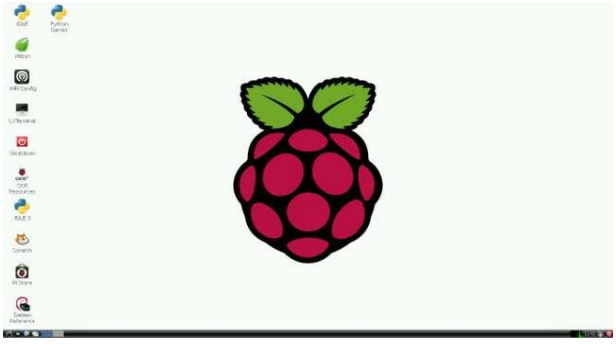
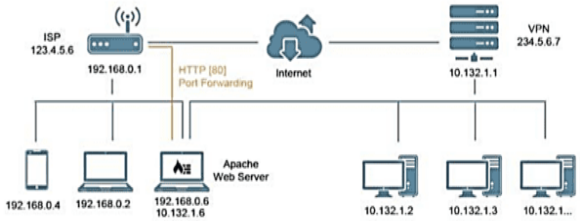


Fig. 12: Raspberry pi OS

Apache Web server:

Although we call Apache a web server, it is not a physical server, but rather a software that runs on a server. Its job is to establish a connection between a server and the browsers of website visitors (Firefox, Google Chrome, Safari, etc.) while delivering files back and forth between them (client-server structure). Apache is a cross-platform software, therefore it



works on both UNIX and Windows servers.

When a visitor wants to load a page on your website, for instance, the homepage or your "About Us" page, their browser sends a request to your server, and Apache returns a response with all the requested files (text, images, etc.). The server and the client communicate through the HTTP protocol, and the Apache software is responsible for the smooth and secure communication between the two machines.

Apache is highly customizable, as it has a module-based structure. Modules allow server administrators to turn additional functionalities on and off. Apache has modules for security, caching, URL rewriting, password authentication, and more. You can also set up your own server configurations through a file called .htaccess, which is an Apache configuration file supported with all Hostinger plans.

7. BLOCK DIAGRAM

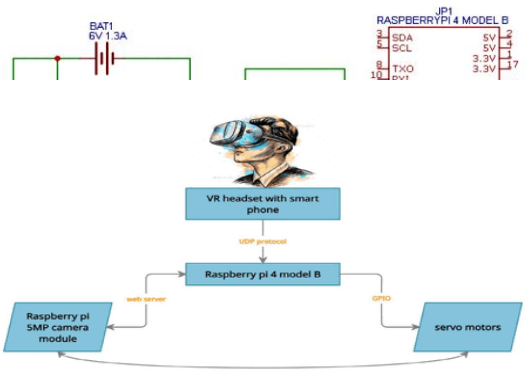
Block diagram of wifi controlled robot:

The block diagram describes that blynk acts as a server for the robot which gives commands to the ESP8266 wifi module through wifi and that command's inputs are given to the motor driver L298N that's output is connected to the pair of motor which drives those motor in either direction according to the command from the server by the user using blynk application. And the motor driver and the wifi module is powered by lead acid battery.

Block diagram for Raspberry Pi camera movement:

This block diagram describes that the readings from the mobile phone inside VR box send the IMU sensor values to the targeted IP and PORT of the raspberry pi through UDP protocol which is used to map the head movement of the user so the PWM signals according to the readings are sent to servo motors. The raspberry pi 5 MP camera module is connected to CSI port of the raspberry pi which live stream the footage on the web page. Then finally the camera module and the servos are arranged in the gimbal.

8. CIRCUIT DIAGRAM



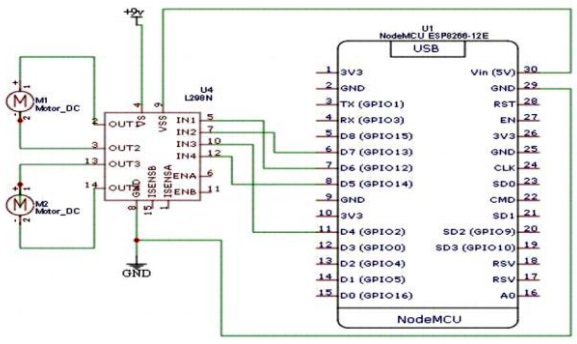
Circuit diagram of Rpi camera movement with servo motors:

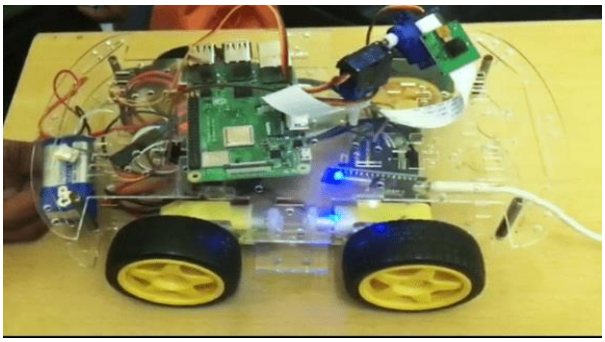
This circuit diagram describes that the two servo motors SG 90's pulse pins are connected to the PWM pins GPIO 13 and GPIO 12 of the raspberry Pi 4 and the positive terminal of the servo are connected to the external power supply 6v lead acid battery's positive terminal and the black pin of servo is connected to the negative terminal of the external power supply and the any one ground pin of the raspberry Pi 4 is commonly grounded with battery's ground.

Circuit diagram for Wi-Fi controlled robot:

The circuit diagram describes that the motor driver (L298N H - bridge driver) is connected with the microcontroller (Node MCU, which comes with the ESP-12E module containing ESP8266 chip having Tensilica Xtensa 32-bit LX106 RISC microprocessor). The input pins of Motor A (IN1 & IN2) in L298N driver are connected to the node MCU digital I/O pins (D6 & D7). The input pins of Motor B (IN3 & IN4) are connected to the digital pins of node MCU

(D4 & D5). The L298N driver output pins are connected to the geared motors of the robot. These input and output pins are connected in order to control the speed and rotation of the motor. The microcontroller is provided with a local hotspot to receive commands.





9. RESULTS

ADVANTAGES

- It allows real-time two-way collaboration between people who aren't in the same location. They are able to speak as if they are in the same room and share data with ease. This technology allows for greater communication and collaboration and provides benefits to your business.
- Stereoscopic vision aids the operator in their tasks because it lets
- the operator view the object under investigation as if they were seeing through the “eyes of the robot.”
- Brings down corporate travel costs.
- Does away with the fatigue occasioned by long journeys for work.
- Makes telework easier.
- Reduces CO2 emissions.
- Allows people unavoidably elsewhere to be virtually present at meetings/in the office.
- Has lots of future potential.

10. APPLICATIONS

This robot can be used as a surveillance robot. In situations where the house owner needs to keep an eye of what the servant is up to at home.

- In the case of military, instead of sending a soldier to a sight for monitoring the robot can be sent. In this way, even if there is an unexpected attack no life is lost only the robot is under damage.
- In the Medical case, at times when the doctor is not able to go on rounds, the robot can be used to check the state of the patient.
- If the robot is made fire proof, then the robot can be used in fire and rescue operations.
- On further expansion of the robot and increasing its connectivity, the robot can be used in space research.
- It can also be used in life threatening mining sites where the lives of workers are in danger.

Fig. 20: A look from another angle

11. FUTURE SCOPE

In order for video transmission to happen a Wi-Fi connection is required. Over a LAN the transmission is almost instantaneous but it keeps varying over slower Wi-Fi. High speed internet connectivity can solve this problem. The directional data are transferred as the head moves. In the case when the head moves very fast the data transfer rate is high. This in turn requires the Raspberry Pi to process the data very quickly. The app should be programmed in such a way that the Raspberry Pi board gets enough time to process the data and prove it as input to the servos. The currently designed robot is suitable to run over smooth surfaces.

User wants telepresence all the time. Every user want it to be available and effortless to use like a mobile phone. In effect, it is need that telepresence to be taken to the next dimension, one that allows for high-intensity collaboration. As with any disruptive technology, the long-term success of telepresence will hinge on its ability to innovate to meet new user demands. In the consumer realm today, people are putting up with poor-quality video and limited functionality for a free service. But enterprise users are seeing the organizational efficiencies and business process transformations that telepresence can deliver, driving the demand for more sophisticated technology.

Stronger body of the robot allows it to run over rougher terrains. The things learnt during the implementation of this project will be used in the next design. We will be able to implement both autonomous and semi-autonomous system. It will support follow the person and reach the destination function automatically. This autonomous function can be designed using machine learning, artificial intelligence and neural networks. It will support

collision avoidance and automatic driving. The physical structure of the robot can be improved for performing various types of tasks like picking items, opening doors, etc.

12. CONCLUSION

With the successful integration of the hardware and software components, the Virtual reality robot moves almost simultaneously with the robot operator. Positions are successfully obtained by the Wireless IMU app and sent to the servo controller raspberry pi and the robot controller via the PC. This unilateral control method provides the human operator with visual telepresence and enables him/her to remotely control the robot solves the lack of cost-efficient telepresence robotic platform for complete and immersive remote operation, with stereoscopic machine vision and suggestive feedback and ready deployment in indoor environments such as hospitals, museums.

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