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The Nextgen Bot

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Abstract
Un-manned 360 (photo or video)capture and control of the bot from any given loca-tion.The backbone and the pith idea of this project is to replace human intervention by bot during rescue operations carried out because of natural calamities like floods, fire breakouts or even during a terrorist attack.The concept is that the bot will imitate the actions of the human being, both of them will be in two different locations and the bot would be controlled remotely in the place of rescue operations.This bot works as a surveillance bot that will reach out to people who are in need of help thereby reaching areas where human figures fail to achieve.

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I. Introduction to The NextGen Bot

The main aim of this project is that the bot will imitate human motion in the situation where human intervention is not possible or maybe lethal. Unmanned control of the bot from any remote location is what we are aiming to achieve[1]. Although human figures can be present at certain places during emergency but it is not possible to be available everywhere and enter all places.So the idea of a bot is being implemented wherein this bot can act as a surveillance bot as well as a bot that can emulate human actions and achieve the given goal in any situation. Using IoT and Node MCU,it is possible to make a bot imitate the actions of the human controlling the bot. The human controlling the bot will be able to view the scenario that is displayed in front of the bot and will perform the necessary actions that is conducive to the given situation which will in turn act as an input to the bot so as the bot can imitate the given actions.

Hand-gesture-controlled-robot

A Robot is an electro-mechanical system that is operated by a computer program. Robots can be autonomous or semi-autonomous. An autonomous robot is not con- trolled by human and acts on its own decision by sensing its environment.Majority of the industrial robots are autonomous as they are required to operate at high speed and with great accuracy[1].But some applications require semi-autonomous or human controlled robots.Some of the most commonly used control systems are voice recognition, tactile or touch controlled and motion controlled. In this project, a hand gesture controlled robot is developed using potentiometer and the controller part isNodeMCU wiFi module.

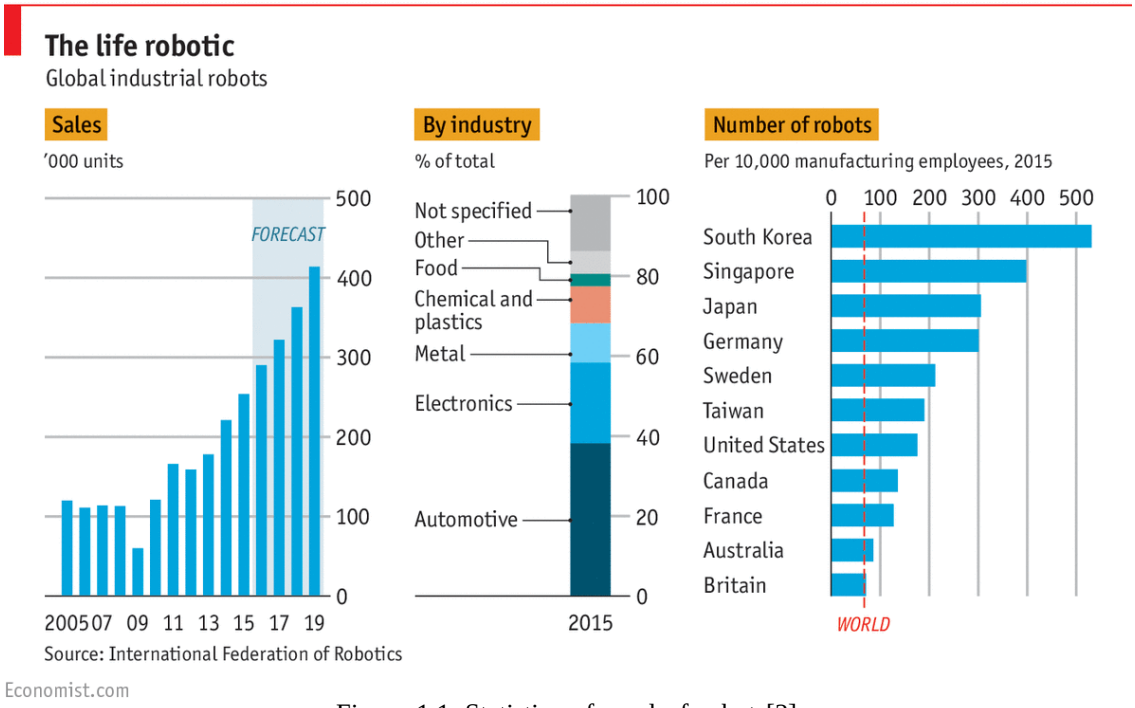

Figure 1.1: Statistics of need of robots[2]

Complications of Remotely controlled systems

Remotely controlled systems which can be controlled from anywhere ,which does not have any range restrictions may cause certain complications which includes:

1. Network speed
2. Lags in actions
3. Remote viewing
4. Remote controlling that can be difficult at times.

How we approached remote controlling of our bot

To control our bot remotely we used Firebase and blynk server, **Firebase**: It is a real time database used for storage as well as communicating be- tween apps, webapps, and arduinos. In this project we used firebase as a medium to communicate between two NodeMCUs which is controlled throght gesture and Blynk server. We faced issues of lags and network speed, but when there is good network coverage it works best. **Blynk**: It is backend server and app which can be used for both backend and as an app.

Need Of Project

The motivation of the project is that many lives are being sacrificed in the course[3] to save others during a natural calamity, terrorist attacks, fire breakouts etc. The significance is that the human intervention is not needed which will ensure saving a life and if the bot is made to imitate human action which is in control of the person who is trained to do the same during such emergency situation, automatically saves the other life too. But the only difference will be, instead of that person physically being present at the scenario, the bot will be present for the rescue or to imitate any action or operation required at that moment. The application is not limited for just[11] rescue operations but many more which is discussed in later part of this report.

Existing System

Exo-Skeletons

Exoskeletons are wearable devices that work in tandem with the user[3]. Exoskeletons are placed on the users body and act as amplifiers that augment, reinforce or restore human performance. Exoskeletons can be made out of rigid materials such as metal or carbon fiber, or they can be made entirely out of soft and elastic parts[3]. Exoskeletons can also be referred to as: robotic suit, powered armor, exo-frame or exosuit, wearable machine, power jacket, etcderiving a simple definition of what an exoskeleton is canbe quite tricky.

Objective

- The main objective is to obtain the real time movement of the bot as requiredduring that specific situation.
- The bot can be anything ranging from a vehicular bot (currently working) to ahumanoid bot (which is the future aspect of this project)
- To achieve the action gestures from the bot without any lag issues or commu-nication issues.
- To receive datas from NodeMCUs which is a development board built on At-Mega for analytics of further acheiving more reliable communication.
- To make user friendly controls for users and make it more secure.

Scope

- The proposed system[4] will help the people who are stuck in an area wherehuman figures cannot reach.
- The system will act as a surveillance system,as a bot that could help the peoplein need.
- It will behave as a human such that the bot will imitate the actions of the human who is controlling the bot. The range of the bot has no limits wherein the human can control the bot from any given location

Application

- Unmanned aircraft systems provide the ideal solution to the problems and lim- itations faced by other surveillance methods. Drone surveillance presents an easier, faster, and cheaper method of data collection, and a number of other key advantages. Drone planes can enter narrow and confined spaces, produce minimal noise, and can be equipped with night.

- Surveillance of occupied spaces and enemy territory and also for rescue opera- tions and in many military purposes.

- We can also use it for wildlife photography and to capture photos where it is impossible for a human to reach.

- A virtual reality headset is a head-mounted device that provides virtual reality for the wearer. VR headsets are widely used with computer 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, structured light systems etc.). Some VR headsets also have eye tracking sensors and gaming controllers

Organization Of The Report

Chapter 1 Describes the Introduction of project, application, and scope. Chapter 2 Describes Literature survey which ellaborates about various existing systems. Chap- ter 3 Describes about drawbacks of the existing system and description of the current system and use of components used in current systems. Chapter 4 Describes the de- signs of existing systems and our current system and workflow. Chapter 5 Describes Modelling of our project and data flow diagram. Chapter 6 Describes results and discussions about this project. Chapter 7 Conclusion and Future Scope.

II. Literature Survey

Wi - Fi Controlled Robot using Node MCU

In the paper[5],Raj Kumar Mistri has presented that The Field of robotics has been exponential growth with the amalgamation of multiple domains. The holistic ap- proach is proving to be a boon, where communication engineering, mechanical engi- neering, embedded system and so many more are together creating robot with high flexibility. Present technologies can only control robots up to a radius of 500 meters, but our aim in this project is to target controlling a robot from a remote location which is more than 1000 miles away. We use WIFI as the medium for communication.

Internet of Robotic Things:Concept,Tech-nologies, and Challenges

In the paper[6],Partha Pratim Ray presented that IOT allows many applications that are very unique in nature and allows addressable things to communicate with each other like microcontrollers to itself and microcontrollers with other things or objects that can connect with internet. Although progressive advancements are made in this field we are getting many challenges which restrict the growth in this field.

Robots are constantly getting enriched by easy development process, such vertical robotic service centric silos are not enough for continuously and seamlessly supporting for which they are meant for.

IoT and Robotics: A Synergy

In the paper[7],Ankur Roy Chowdhury presented Synergy means adapting to user requirements and interaction patterns, these requirements modifies itself as a set of design principles for every layer in IOT. The aspects of Cloud Robotics and its role in aiding functions like sensing, manipulation, and mobility are considered as a tremendous advancement in the field of Internet of things. The examples of these areIntelligent transportation System endowed by an IoRT-inspiresd architecture.

Wireless Controlled Surveillance Robot

In the paper[8],Ajay Singh Rajput and Kunal Borker as presented Wireless controlled surveillance bots are in huge demands as of todays world is concerned, bots which can be remotely controlled can be used to go anywhere humans cannot go. Bots can be wirelessly/remotely controlled using two ways, one by using bluetooth, but it has a short range and an another better way is by using wifi or internet. We can controla bot from anywhere using internet with your mobile device or any other hardware device.

Development of robotic arm using Arduino-Uno

In the paper[9],This proposed work is an overview of how we can make use of servo motor to make joints of a robotic arm and control it using potentiometer. Arduino UNO board is programmed to control the servo motors and arduino's analog input is given to potentiometer. This modelling resembles like a robotic crane or we can convert it into robotic crane using some tweaks. Robotic arm is one of the major projects in today automation industries. Robotic arm is part of the mechatronic industry todays fast growing industry. This project is apick and place robotic arm. On large scale it can be used as in environment, which is either hazardous (e.g. radiation) or not accessible. As the size of the robots scale down, the physics that governs the mode of operation, power delivery, and control change dramatically, restricting how these devices operate This also include it's characteristics like its extension, positioning, orientation, tools and object it can carry.

Integrating robots into the Internet of Things

In the paper[10],Cristina Turcu presented According to various reports, the number of robots used worldwide is constantly increasing. They are more and more present in different workplaces such as manufacturing, processing operations, dangerous areas, medical environments, military, inaccessible areas etc. Also, robots are able to do so- cial works like assisting people with disabilities or even playing when toys are robotic techniques based. In our days ICT applications became more complex while includ- ing various technologies such as wireless communication, wireless or embedded sensor networks, virtual reality, artificial intelligence, cloud computing/storing etc. Due to the new IPV6 protocol every entity in this world could be uniquely identified and be a part of an infrastructure that enables connections between different entities (living or non-living), using different but interoperable communication protocols. Further- more, everyday entities are becoming either source of information or consumer or both, having communication capabilities and being able to collectively solve complex problems. But, where are the robots? First developed as a tool, nowadays a robot can be integrated as an entity in the new paradigm of Internet of Things (IoT).

Geolocation using NodeMCU

In the paper[11],Rumi Juwairiyyah has presented that Geolocation is defined as the identification/estimation of the real-world geographic location of an object, such as a radar source, mobile phone, or Internet-connected computer terminal or any other device. Apparently, geolocation involves the generation of a set of geographic coordi- nates and is closely related to the use of positioning systems, it is enhanced by the use of these coordinates which determine a meaningful location, such as specific area. In this project, we will be interfacing a GPS module with NodeMCU. A simple local web server is created using NodeMCU and the location details are updated in that server webpage. NodeMCU is an open source IoT platform. It includes firmware which runs on the ESP8266 module and hardware which is based on the ESP-12 module. ESP8266 can be used for geolocation by firstly obtaining nearby AP properties, and then using Google geolocation API to locate the user-device. To be able to obtain a fix on the location of the or cellular sub-systems. The data is consolidated into a data block that must be sent to an online geolocation API or service that will estimate the device location in terms of latitude, longitude, and accuracy.

III. Existing technologies

Report on Present Scenario

Surveillance drone

One of the methods used for surveillance is drones, and they all have their lim- itations. Drones are agile and more able for surveillance but they involve trans- mitter and receiver which have a limited range and cannot cover a large area due to connectivity issues as a human presence is needed within a range of 10m (if drone is controlled via WiFi). Even if the drones are connected with satellites and use satellite communication for surveillance then too, they can adapt a range of around 10-14 km maximum. There are also bots same as drones with limited range.

Use of Firebase and Blynk to increase range

Recently emerged technologies like Firebase and Blynk are used extensively in IOT (Internet of Things) field. We are using these technologies to make our bot rangeless and to control it on any terrain and at any given distance.

Drawbacks of Existing System

The drawbacks of the existing system i.e surveillance drones, exo skeletons and bots have limited range and can lose connectivity after certain distance because a trans- mitter used in a drone can transmit data upto a certain distance depending on the product. Also for image capturing and rendering you would have to depend on the network and live stream is restricted. In our bot the controlling can be done by both gesture and mobile (via app).

Problem Definition

Many lives are being sacrificed in the course to save others during a natural calamity, terrorist attacks, fire breakouts etc.The significance is that the human intervention is not needed which will ensure saving a life and if the bot is made to imitate human action which is in control of the person who is trained to do the same during such emergency situation, automatically saves the other life too.But the only difference will be, instead of that person physically being present at the scenario, the bot will be present for the rescue or to imitate any action or operation required at that moment.

Proposed system

As shown in the diagram, we can see the actions which is needed can be given either through gesture or by usual button commands, wherein the bot will perform the specific motions. Gesture control can be achieved through potentiometer values and firebase. And also we have established the joystick control through mobile about which we will discuss later in the report.

The slow of the execution goes by:

- The person/user wears VR (Virtual Reality) headset for remote viewing and bot vision of our bot, the vision will be displayed via app which is remotely connected to IP camera.

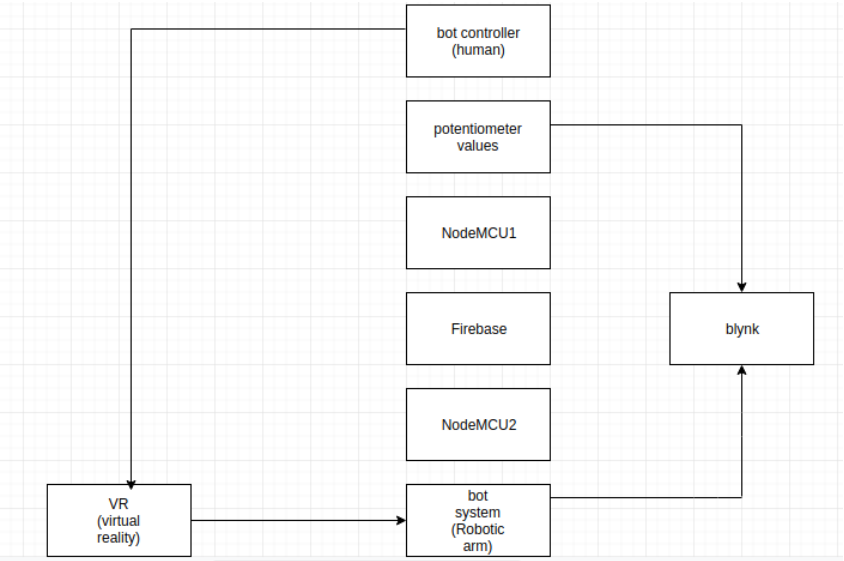

Figure 3.1: Workflow of bot

- Then the person can wear prosthetics for controlling and gesturing bot arm, as soon as he makes any gestures, the same will be performed accordingly by thebot arm to pick items or just for some actions.

- The gesture of user triggers the movement of potentiometer and the value of it changes and is processed by NodeMCU placed on prosthetics and pushed to Firebase in real time. Firebase then passes the same data to NodeMCU mounted and interfaced with robotic arm / bot arm.

- NodeMCU then moves servo motors according to the value it gets via Firebase, so there is a transmitter NodeMCU and receiver NodeMCU.

- The movements can also be controlled by Blynk which connects the app to NodeMCU directly and commands can be passed directly to NodeMCU as you can assume this method is more reliable and faster as compared to the previous one.
- To control the vehicular bot we again use blynk, this time to control the DC mo- tors and for GPS tracking which uses GPS (Global positioning System) module

- The surroundings of the bot can be viewed by the user and he can control the bot easily by just integrating his prosthetics and mobile with Blynk or Firebase,accorfing to his requirements.
- Both Firebase and blynk controlling has their own perks and cons, in Blynk the movements are much faster and more reliable but in Firebase, even the slightest movements can be triggered and controlled as it is gesture part.

IV. Design and Methodology

Model

In this the current design model of the bot is explored and explained. The bot model is divided into two main parts:

1. Vehicular body of the bot.
2. Arm of the bot.

Vehicular body of the bot.

Two DC gear motors(300rpm) are used for the movement of the bot.A wooden body for endurance is being used. Even during the case of colliding and crash the strength of the bot is retained without damaging the other elements of the bot. Two wheels with the DC motors are attached to both the sides of the both and two free rotating wheels are attached to the front and rear of the bot to maintain the steady and flex-ible movements. The two motors is powered by 200mAmps 5v battery.

The command for the motors is sent through L293D motor driver attached to the Node MCU.GPS module is mounted on the bot so as to gain the current location.MI Camera is fixed at the top of the bot. This camera acts as the robotic vision. Live stream capture, image capture, storage in sd card or even cloud is possible through this camera. Robotic arm is placed besides the camera so as to imitate the gesture movements by the controller. Through the vision, the controller will know about the scenario around the bot and will respond accordingly and the actions such as picking up a light weight object can be done by the robotic arm.

Figure 4.1: The body of the bot

Design of Robotic arm

The arm mounted on the body can be controlled in two ways, either through the gesture or even through mobile application. In gesture control, the controller wears the prosthetics which includes potentiometer as the sensor to send the data about the action through a Node mcu.The data from the potentiometer is sent through the node mcu to the firebase. Here the real time changes in the potentiometer can be seen. This change is reflected to the other node mcu mounted on the bot with the arm. The motors of arm receives the data from the node mcu powered by 5v power bank. The robotic arm involves moments of wrist, palm and forearm. This movements helps to pick and place light objects.The movement of the arm is carried out through three5v servo motors.

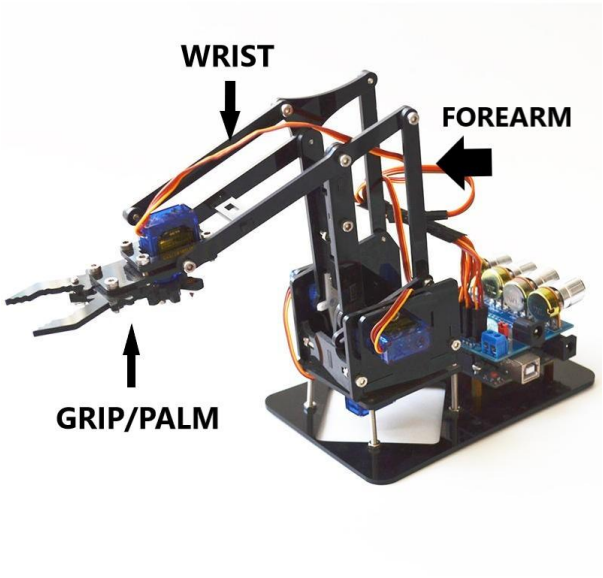

Figure 4.2: Robotic Arm

Methodology and working

Here there is the explanation of workflow and methods of execution of our project.

Communication and control of bot

The bot is controlled by NodeMCU and blynk backend server, person will be wear- ing a vr headset to have the robot view experience. For gesture control, he would just gesture the motion required to wear prosthetics which has potentiometer and its values are passed to firebase in real time and the relative actions will be performed

Firebase

Figure 4.3: Firebase Real Time Database[12]

by our bot arm. For joystick control, he would have the joystick in hand and would be trained prior to the execution about the corresponding buttons and control (as of now we are controlling through mobile, which acts as a joystick) The commands are pushed via internet and received at the bots end. Firebase is the major and most pop- ular real time database system through which the real time changes can be achieved. Also

there are many database systems that are similar to firebase for example blynk, through which the real time movements can be achieved easily. Hence via firebase or blynk kind of real time databases we can send the instructions and can see the real time execution of the same by the bot. The bot, if it is humanoid will be mountedwith the exoskeleton, which will be helpful in lifting heavy objects.

Figure 4.4: Blynk workflow

Blynk control

Blynk is the major aspect of this project it is the component that is making the communication between the NodeMCu and the app possible. Blynk is a software application that can be used as an app buider as well as a backend server for com- munication of IOT devices (sensors).

NodeMCU

NodeMCU is a development board which has inbuilt microcontroller IC Atmega328p. It is an open source IOT device, it has inbuilt WiFi module ESP8266 through which we can communicate between web apps and internet.

NodeMCU is the processing unit in this project which can be explained in many ways: NodeMCU is the component that is controlled by blynk and firebase to acheive real time actions and communication between bot, bot arm and user.

Figure 4.5: NodeMCU[13]

The user does some actions which is processed by NodeMCU (it takes potentiometer values which changes according to user action). Then the processed values are exe- cuted and the bot moves according to the commands given.

Firebase and blynk limitations

What is wrong with firebase ?

Firebase is a real time database no doubts, but when it comes to reliability it is not that reliable because of the continuous flow of datas through the server they tend to lag many times. Also when there is a slight network issues there will be a huge difference in action imitated by the bot. Firebase has its own advantages and disadvantages, we have to use it wherever neccessary and its at its best. Firebase cannot perform well in circumstances where the user tends to move or perform action faster and the precision is severely disrupted. Firebase is great to get sensor datas but to perform actions and human gesture it is slightly slow and unreliable.

How we overcame it

We used ranges to overcome the firebase lag and slow response issues. We parted thepotentiometer values by some ranges like: 10-40, 40-70, 70-150,.....till the maximum value of firebase. By doing this our accuracy got higher and data processing becamefaster.

- Potentiometer values are optimized for better results , and range was defined by which the firebase was more adaptable to changes and was much faster than earlier.
- We are also using alternative method for communicating / controlling the bot that is via Blynk, so that at times there will not be a situation where the bot cannot be controlled.
- For the free movement of robotic arm we are using lightest materials such as cardboard or plastic (3D printed), because the servo motors which are used for controlling the bot arm must be flexible and should be able to adapt faster with the user actions.Servos cannot lift heavy materials apart from the bot arm weight and can struggle with the movements
- The bot movement and remote surveillance was also another challenge, so we used the IP camera for remote surveillance and remote monitoring. The bot movement can also sometimes delay due to network issues.

V. Results and Discussions

Implementation

Movement of the vehicular bot

The blynk server is used for controlling the vehicular bot.The movement of the vehic- ular bot is controlled using control buttons implemented in the blyk app. There are four buttons provided in the application.Each buttons depict corresponding motion of the vehicular bot.

The corresponding[14] four controllers are as follows:-

1. Right
2. Left
3. Forward
4. Backward

As soon as the[14] buttons are pressed,the corresponding actions takes place from any given location through internet.The ESP8266 NodeMCU wiFi module connected on the receiving side must be online i.e it must be connected to internet. As it is online,it receives the command or button inputs through blynk application and the DC motors connected to the nodeMCU receives the signal inputs and the bot moves in a given direction.

Geolocation using nodeMCU

The location of the bot is determined using GPS module.The GPS module is con- nected to ESP8266 NodeMCU wiFi module. Then the connection is mounted on the vehicular bot so the location of the bot is displayed on the app. The blynk app has maps function which displays the sector in which the bot is currently located.

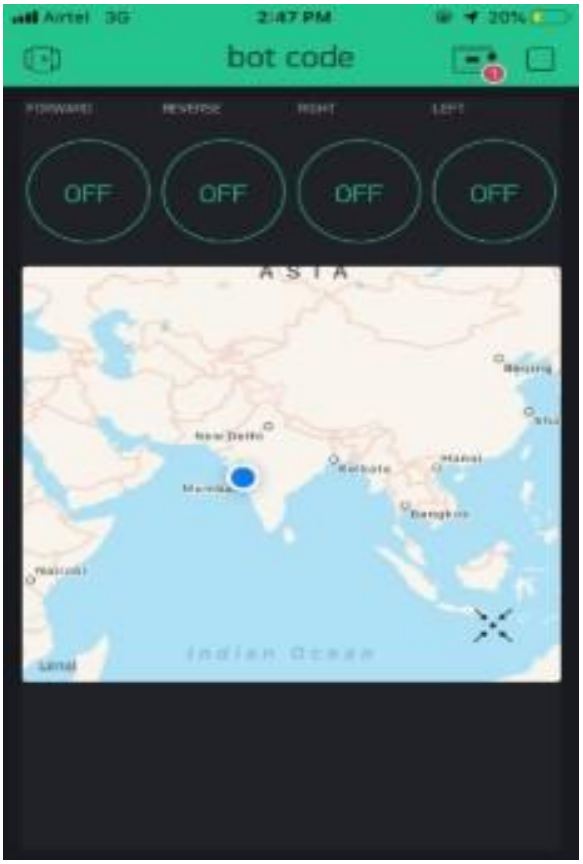

Figure 5.1: Geolocation and Controlling buttons.

Implementation of movement of the arm

The robotic arm is mounted on the vehicular bot.The arm has the following subparts:

5. Claw
6. Wrist
7. Forearm

The movements of the claw,wrist and forearm is controlled using the prosthetic arm. The prosthetic arm is on the sender side and on the receiving side the robotic arm mounted on the vehicular bot acts corresponding to the data values it receives from the sender side. Tat is the data from the sender side is taken as an input on cloud.The cloud ten provides this input to the receiving part where the values are mapped in a considerable range and the movements of the robotic arm is performed accordingly.

Table 5.1: Mapped values of receiver's side

SR NO	Prosthetic arm values(sender side)	values provided for movement of the arm in angle(receiving side)
1	883	90 degree
2	443	60 degree
3	75	30 degree

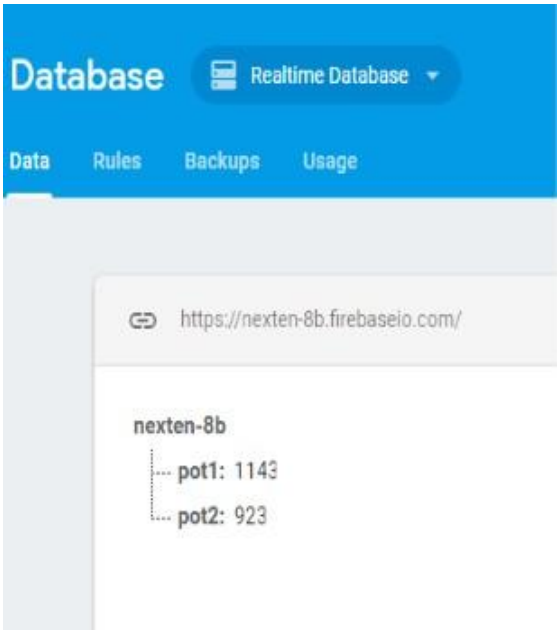

Figure 5.2: Cloud Database of sender's data values.

Results & Analysis

Fig 6.2: Bot vision Fig 6.3: Arm

Figure 5.3: Model of the bot

Losses

Two types of losses can be expected, one at the controllers end and another at the receiver bot end. Since the pith of the project depends on the Internet, without the availability or the delay in the network will cause the loss of goal accomplishment. This includes if the network is weak at the senders end, then the actions or the commands given to the bot will get delayed upload of the data.On the other hand if the the network is weak at the receiver bot end, then the task to be implemented will have delayed affect which might be really of no use in an emergency situations. Also the value is mapped from potentiometer to the servo angles used for robotic arm movements on the bot and there are losses during this mapping. In this we cannot expect the exact value at both end simultaneously at the very same time.

Accuracy

The graph plot shows the relation between the potentiometer values of the prosthetic worn by the controller and the angle at which the servo motor rotates in the robotic arm.

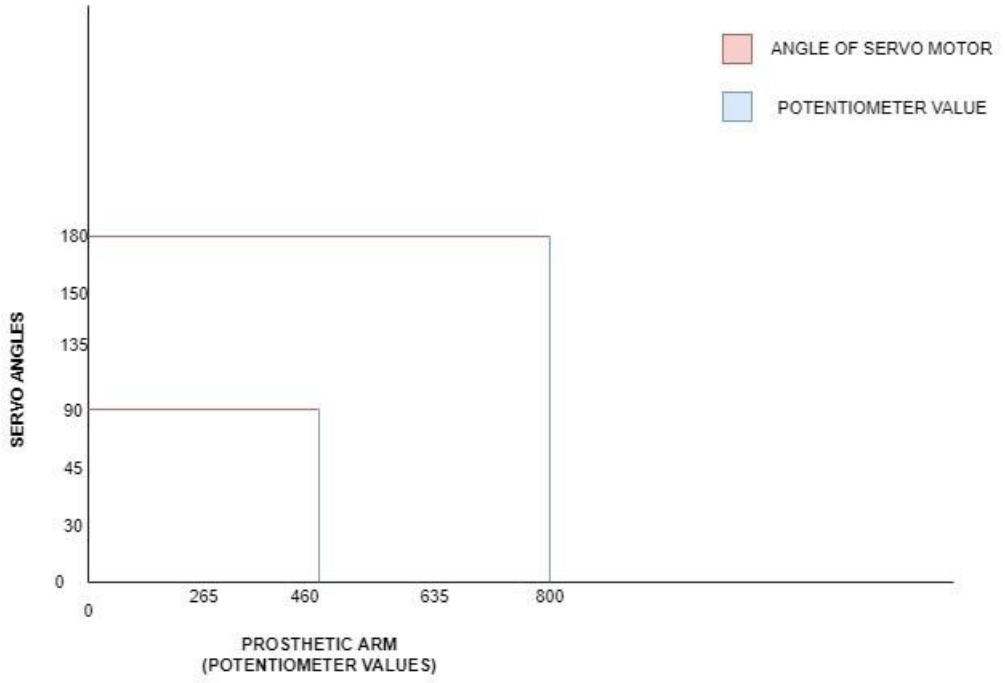

Figure 5.4: ACCURACY

Analysis

The table shows the results of testing both movements of the bot as well as the move- ments of the controller through a range of values and the accuracy which is achieved.

Table 5.2: Testing Accuracy

Method	Pot values	servo angles(in degrees)	Accuracy %
Firebase	60	30	70
blynk	200	60	75

VI. Conclusion and Future Scope

In this paper, we proposed an innovative approach [15]to pick and place any light weighted object from any remote location using VR where it shows the vision of the bot. For the motion of the bot, we make use of very simple yet effective blynk server through which the motion of the bot is controlled. For the arm movement of the bot,we have used firebase as a medium to pass data from the sender side to the receiver side. The location of the bot is traced by GPS module. As for future work, we will put efforts in implementation part in enhancing [8] the vehicular bot to a humanoid bot in order to imitate the movements of the human from any given location.

References

[1]. crls research guide, http://www.crlsresearchguide.org/17_Writing_ Introduction.asp
[2]. The Economist: https://www.google.com/search?q=robot+stats&source= lnms&tbm=isch&sa=X&ved=0ahUKEwjy0ZrI0OjhAhUpmuAKHbIBCuAQ_AUIDygC& biw=1366&bih=657#imgrc=6u-jzYEw9EA9UM:
[3]. bibitem Preparation of a Formatted Conference Paper : https://www. ieee-pes.org/images/files/pdf/pg4-sample-conference-paper.pdf
[4]. Robotic exoskeletons: The current pros and cons: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6153133/
[5]. https://www.workfront.com/blog/how-to-write-a-project-scope
[6]. Raj Kumar Mistri " Wi - Fi Controlled Robot using Node MCU publised in International Journal of Engineering Development and Research,"Published in 2018.
[7]. Partha Pratim Ray "Internet of Robotic Things: Concept, Technologies, and Challenges," Published in 2017 IEEE.
[8]. Ankur Roy Chowdhury, "IoT and Robotics: A Synergy,"Published in 2017 IEEE.
[9]. Ajaysingh Rajput and Kunal Borker, "Wireless Controlled Surveillance Robot,Published in International Journal of advance research on february 2014.

[10]. Priyambada Mishra,Riki Patel,Trushit Upadhyaya,Arpan Desai. "Development of robotic arm using arduino-uno" published in International Journal of Recent Researches in Science,Engineering and technology in 2013.
[11]. Cristina Turcu, Cornel Turcu and Vasile Gaitan "Integrating robots into the Internet of Things,"Published in International journal of circuits,systems and signal processing, published in 2012.
[12]. Rumi Juwairiyyah,Kajal Kasat,Jyothsna Bhushan,Mr. Jayaraj "Geolocation us- ing NodeMCU,"Published in International Journal of Researh,Ideas and Innova- tions in technology.
[13]. https://medium.freecodecamp.org/firebase-and-react-hooks-eb892fa
[14]. https://ecp.engineering.utoronto.ca/resources/online-handbook/components-of-documents/results-and-discussions/
[15]. https://www.google.com/url?sa=i&source=images&cd=&cad=rja&uact=8&ved=2ahUKEwjy4djj1OjhAhVNdt8KHU4MAZcQjRx6BAgBEAU&url=https%3A%2F%2Fwww.amazon.in%2FLolin-NodeMCU-ESP8266-CP2102-Wireless%2Fdp%2FB010O1G1ES&psig=AOvVaw3ijUHPK1Zv-rT59zpKP-AO&ust=1556192980737205
[16]. Ankit Dhamija "A novel cryptographic and Steganographic approach for sources cloud data migration,"published in International Conference on Green Comput-ing and Internet of Things.