# *IoT based Voice Controlled Home Assistance Hexapod*

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***Abstract*—IoT-assisted robotics applications are a palpable fact of our forthcoming future, thanks to the ongoing Internet of Things revolution and the rapid dispersion of robots in many activities of daily life. IoT based Hexapod is one such application which can be used for various purposes from hospitals to the military which has serious upsides in the current and future generations. This work aims to design a hexapod for helping people, especially old-aged or sick people at home with automation, voice based navigation and surveillance. Sensors are used to detect obstacles and the hexapod can choose a different path. Electronic devices in each room are controlled through voice commands. The robot is also designed to help the user by carrying objects like medicines, files, etc., to various areas in the home based on the given commands. The home is monitored and the video will be live streamed for the user to monitor their home from anywhere at any time.**

***Keywords—Hexapod, Robot Operating System, IoT, Path planning, Surveillance, Automation***

## I. INTRODUCTION

Robots are replacing humans in almost every sector, they get the job done more precisely and quickly. It is expected that the stock of robots could reach almost 20 million by 2030, with automated workers taking upto 51 million jobs in the next decade. They will eventually become integral parts of our daily routines. Similarly, Internet of Things is also gaining popularity in the recent times.

For most of the technical history, the focus has been on making technologies connect with humans or using devices to communicate with other humans. From switching on the appliances to controlling the room temperatures, Internet of Things concept is applied. The internet is utilized to send emails to other humans, keep tabs on them on social media, and buy items from them. The goal of the Internet of Things is to reduce human involvement in the communication network. The internet becomes a network of gadgets talking to one other, rather than a network of persons connected through technologies. The Internet of Things is essentially a network of things that can communicate with one another.

Robots can be linked into the Internet of Things infrastructure, allowing for connections between various entities via various communication protocols. The Internet of Robotic Things refers to robots that are connected to Internet of Things technology and can communicate with other objects through the Internet. Intelligent devices can use IoRT to monitor events, combine sensor data from several sources, and employ both local and distributed intelligence to choose the best course of action. This is followed by a physical act of controlling or manipulating objects. A lot of beneficial aspects are driving the worldwide Internet of Robotic Things market. The use of the internet of robotic things is being boosted by the expansion of the e-commerce business and the expansion of application fields due to the integration of robots with various technologies [22]. This market is being driven by the increasing usage of smart devices, automation in manufacturing processes, and the growth of e-commerce. One such application of Internet of Robotic Things is home assistant hexapod. The hexapod is used for different purposes from hospital to military [19][25].

Hexapod robots have 3 pairs of legs which is an advantage compared to wheeled robots since this robot can easily navigate even through rough and uneven surfaces [2]. Each leg has 3 servo motors which adds up to 18 servo motors overall, which are controlled by an arduino. This IoT based hexapod is designed in such a way that it acts as a companion to humans while performing tasks for them.

Google Assistant is connected to the system to accept voice commands from the user. Voice based navigation is an added advantage for old aged people [6][10][23][26]. Another important feature of this robot is surveillance, the camera attached to the hexapod helps in monitoring the home from anywhere using video streaming. Lidar enables the hexapod to identify the presence of an entity and helps in avoiding human-robot collision. It also helps in mapping and path planning. Automation of electronics is done based on the commands given to the hexapod by the user for which Adafruit and IFTTT platforms are used. The data is

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given as input to Adafruit platform which supports MQTT protocol using IFTTT and commands are executed.

## II. Related Works

Abdelrahman Sayed Sayed et al. have worked on a fully autonomous centralized multi robot system specifically for Covid-19 field hospitals. This system is designed in such a way that it performs tasks like disinfecting, detecting remote body temperature.., A master PC is used as a publisher and Raspberry Pi mounted on robots acts as a subscriber. A Kinect sensor is being used to map the hospital area which is also used as a thermal camera to detect people with high body temperature [1].

Abhishek C et al. integrated a robotic system with an embedded system of digital image processing. They have equipped the hexapod with a camera for capturing videos in real-time and a distance sensor to detect and avoid obstacles. The Yolo algorithm is being used to detect objects [3]. Anita Chaudhari et al. have developed a prototype for a quadruped robot using IoT for delivering medicines and essentials to Covid-19 patients. Ultrasonic sensors are used for detecting obstacles. The movement of the robot will be controlled using an android application which can be accessed by doctors and other medical staff [5].

Fernando Gomez-Bravo et al. proposed a hybrid legged-wheeled mobile robot named R3HC. This system was designed in such a way that it calculates optimum path planning trajectories based on the size of the obstacle and power consumption efficiency [8]. Similarly, hybrid control architecture tends to increase body stability[16]. G.Anandravisekar, et al. have built a surveillance robot with metal detectors and a camera for live streaming. Cayenne software is being used to control the robot both in manual and automatic mode [9]. FireBird V robot is the 5th in the FireBird robot series. Mahesh Pawaskar et al. preferred wireless communication between Firebird-V based hexapod robot and the user using Raspberry Pi through WiFi. The activities of the robot are controlled by a webpage through Raspberry Pi and the information about the position of the joystick is fed to Raspberry Pi to move the position of the camera for surveillance purposes [14].

Md. Imran Uddin et al. focused on improving climbing techniques (by using suction cups), walking angles and payload. This model is specifically designed for human safety purposes during disasters like earthquake, fire incidents etc., Infrared sensors are used for detecting dark and light surfaces and a sound sensor module is used for detecting sound. The robot also streams live videos on YouTube with the help of MQTT broker [17].

Mostafa Khazaee, Majid Sadedel and Atoosa Davarpanah have worked on behavior based autonomous hexapod with goal attraction and obstacle avoidance as its main behaviors. They have achieved the results using hybrid automaton [20]. Richik Ray et al designed a quadruped robot using IoT and MATLAB. Webcam for surveillance, operational voice control, checking the health status, battery, direction of the bot, speed check are few features of this robot [24]. Vaibhav Malhotra has proposed a system for helping aged people in airports with their luggages. Self-designed belts are used for recognizing the owner of the luggage using Yolo algorithm. Carrier will be connected wirelessly to the user's phone app by scanning QR code on it [28].

## III. Proposed System and Implementation

The project aims at building an automated six legged hexapod that responds to voice commands to perform tasks. The detailed block diagram of the project is shown in Fig.1. The movement of the hexapod is controlled by arduino using the servo motors attached to each leg. The Lidar is used to collect data about the obstacles lying around the home while mapping the whole house. This data is then used to prepare a detailed map of the rooms. For mapping, the hexapod is manually controlled using a joystick. Once the mapping is done, the hexapod is ready to move around the house and identify the obstacles on its way without bumping into anyone or anything.

Google Assistant intakes the voice commands given and processes it before passing it to the NodeMCU which then pushes the data over to the Adafruit Platform by using the MQTT protocol. The entire process is carried out using Wi-Fi as the wireless technology.

Adafruit along with IFTTT platform is used to automate the electronics in the house based on the voice command received from the user. Live video is also streamed for surveillance purposes.

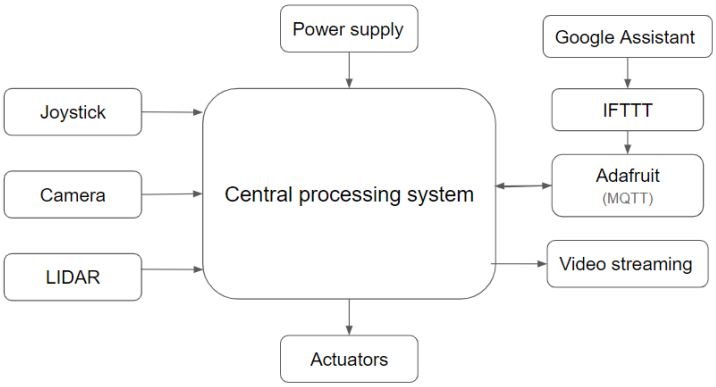


Fig. 1. Block diagram of the six legged robot.

### A. Assembling the hexapod and calibration

The parts of the six-legged robot like femur, base, thigh etc., are 3D printed which are designed in CATIA V5r21 with a full parametric design. Each leg is fitted with 3 MG996R servo motors which are controlled by the arduino. The legs are attached to the body of the hexapod in such a way that the servo motors do not get damaged. A protoshield is included with the Arduino MEGA, which makes attaching the servos to the microcontroller much easier. Each servomotor is connected to the protoshield using 18 tri terminal connectors welded directly to the PCB. The Arduino MEGA comes with an A-B USB cable that connects it to the Raspberry Pi. A 20A UBEC is used to power the servos and the protoshield as shown in Fig.2. A Lidar is integrated with the robot for mapping purposes.

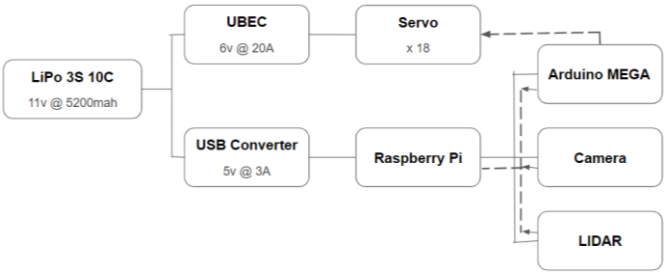


Fig. 2. Electrical system of the hexapod.

Servo calibration is done to stop the hexapod from assuming default calibration values and to reduce error. The hexapod will be in walk position by default when the calibration mode is started after the initial calibration. That suggests the angles aren't the ones used for calibration. If this option is not disabled, the associated servo will move to the desired place every time calibration is done. This mode can be disabled if the movement of the servo is not desirable while calibrating it. The 3 walking gaits, tripod gait, wave gait, ripple gait are adjusted [7][11][15]. Fig.3 and Fig.4 represents the hexapod when it's turned on and turned off respectively.

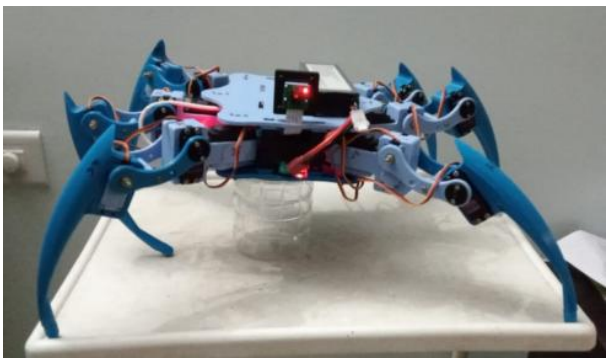

Fig. 3. Six legged hexapod when it's turned on.

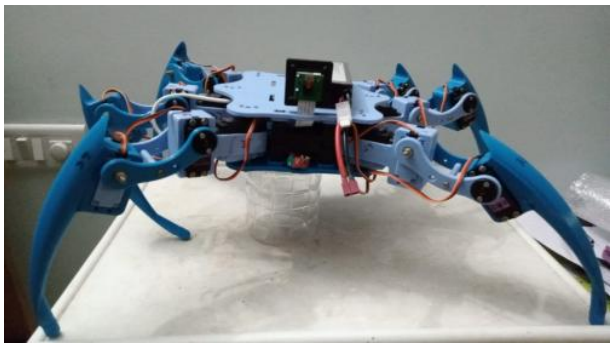

Fig. 4. Six legged hexapod when it's turned off.

Raspbian and the ROS framework are installed in the Raspberry Pi, and the OS is configured in order to remotely connect the hexapod [13]. A 32 GB SD card is used for this purpose. After installing the Arduino IDE, the board is plugged in the Raspberry Pi and required packages are installed. The camera in the Raspberry Pi is also enabled. Fig.5 shows the image of fully assembled hexapod.

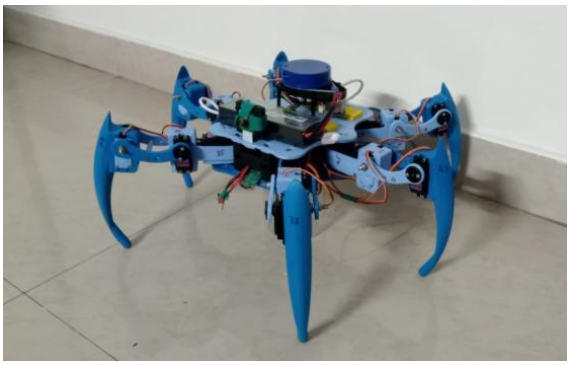

Fig. 5. Fully assembled hexapod.

## B. *Mapping*

The shortest distance between the start point and the target point is calculated using a map based planning method in which the shortest distance is chosen based on the lowest movement cost. The detailed mapping of the house is done using a LIDAR mounted on the top of the hexapod. The LIDAR sensor works based on the pulsed light waves that it emits into the environment from a laser. These pulses then enter the sensor after bouncing off from nearby objects. It is different from IR sensors and ultrasonic sensors which are generally used. This sensor works in the frequency range of 5000Hz with a maximum wide ranging range of 10 meters. The hexapod is manually operated using a joystick to navigate through the maze to draw a predefined map of the rooms as shown in Fig.6. The hexapod will then map the room to identify the obstacles in each room and a path is drawn in such a way that it avoids collision during navigation [12][29][30].

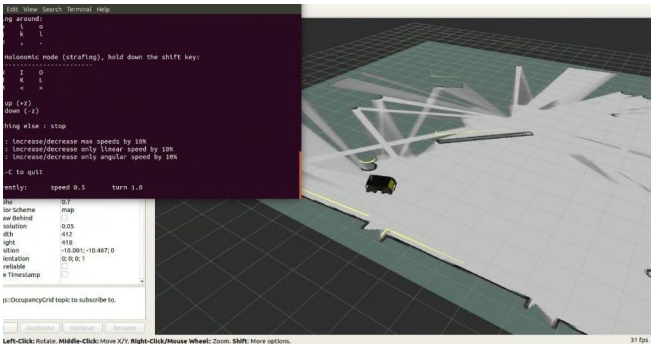

Fig. 6. Mapping the rooms by manually operating the hexapod.

## C. *Surveillance and live streaming*

The surveillance is done using a Raspberry Pi camera module. The camera is mounted on top of the hexapod for a better Field of view. Camera module is enabled in the Raspberry Pi in order to use the camera. The camera is connected to the Pi CSI port. After setting up the camera, the video streaming web server is accessed at the Raspberry Pi's IP address to monitor the house from anywhere and at any time.

## D. *Voice navigation and automation*

Google Assistant linked to the users account is used for giving voice commands to the robot. A speaker is connected to the Raspberry Pi for the hexapod to respond to the voice

commands. The system deals with listening to the audio and performing the actions when the triggering word is stated.

If the user says the predetermined phrase, the function to turn on/off the lights or other electronics is satisfied and the output is either turning on or off the light bulb in the room from which the voice command is given, depending on the command [21]. The feedback is sent in the form of sounds from the speaker.

In the Adafruit platform a new dashboard named 'Automation' is created and two triggers are added to it. The triggers are named Light 1 and Light 2 with values 0 and 1 for switching ON and switching OFF respectively. The Fig.7 shows the dashboard with two triggers. The key is then used to link the Adafruit platform with IFTTT platform.

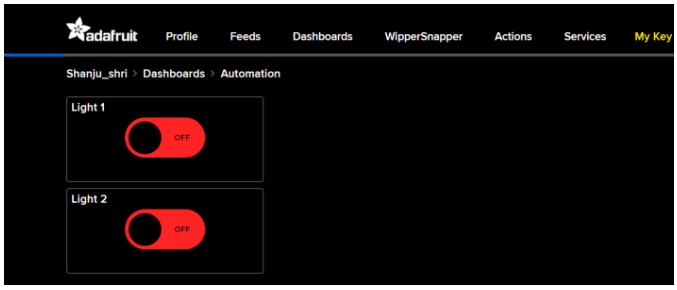


Fig. 7. Adafruit dashboard.

The NodeMCU is connected to the LEDs which represent the electronics in the rooms [27]. The data in the form of voice is then sent to the Adafruit platform through IFTTT. This data is then used to automate the electronics connected to the system. The Fig.8 shows the applets created in the IFTTT platform which triggers the functions to turn on and off the lights based on the given commands.

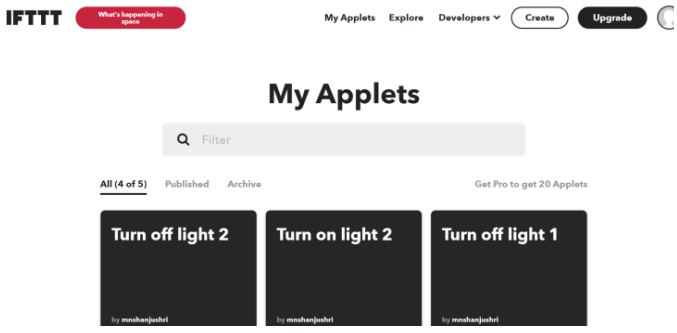


Fig. 8. Applets created in IFTTT.

## IV. Results

The hexapod functions successfully and expected results are obtained. Fig. 9 shows the movement of hexapod based on the directions given by the user. This way, the hexapod reaches the target destination to work on the task given as command. The hexapod moves easily through rough terrains in a stable way. Thus, it is able to carry things without them falling off the hexapod.

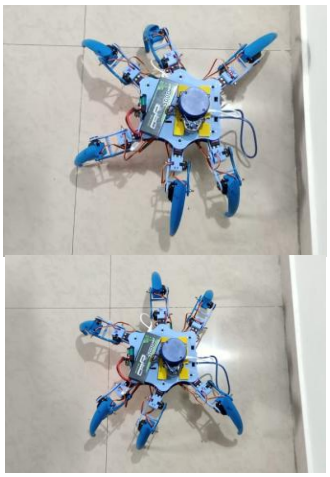

Fig. 9. Hexapod in motion after voice command is given

The camera in the hexapod captures the images and video is streamed in the website. The following images Fig.10 and Fig.11 represent the images captured by it in various areas of the house. Thus the user can monitor the house from anywhere.

Fig. 10. Image of dining room captured by the hexapod camera

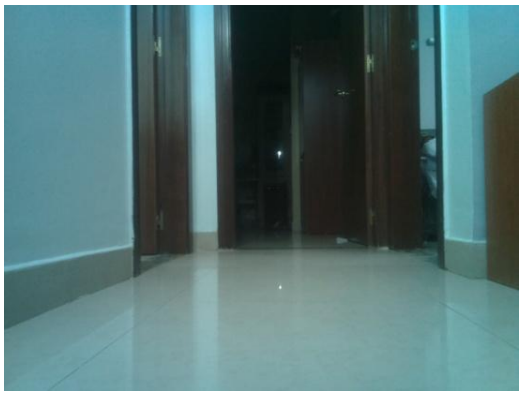

Fig. 11. Image of entrance of bedroom captured by the hexapod camera.

The voice commands are given using the Google Assistant to turn on the lights in the room. Google Assistant passes the commands to the system and responds to the given commands as shown in Fig.12 and Fig.13.


Fig. 12. Voice commands given to Google Assistant to turn on and off light 1.

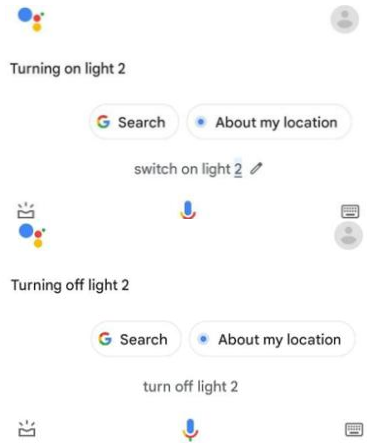


Fig. 13. Voice commands given to Google Assistant to turn on and off light 2.

LEDs represent the electronics in the rooms. When the user commands the LEDs to turn ON and OFF, the tasks are performed accordingly. Fig.14 and Fig.15 represents when light 1 is turned ON while light 2 is turned OFF and both the lights are turned ON respectively.

Fig. 14. When one of the LEDs is turned ON

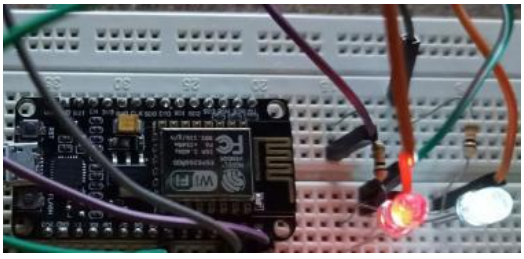

Fig. 15. When both the LEDs are turned ON

## V. Discussion

Home Assistance Hexapod shows some similarities in developing and controlling the robot [4][5][14], but the features and application are vastly different from the previous works. This robot is specifically built to act as an assistant for people at home with features like carrying things, automating electronics and surveillance. Unlike the sensors used in other works, Lidar has a large measurement range and the accuracy is also very good [18]. Technical issues like mismatch of versions of OS and ROS software, and grip at the feet of the pod are sorted out by using older versions and making a DIY feet for extra grip respectively. The IoT platform used is also comparatively user friendly.

## VI. Conclusion And Future Work

The home assistance hexapod acts as a perfect companion and assistance for people at home, especially for sick and elderly people to meet their needs. The main objective of this system is achieved by integrating the Internet of Things with robotics successfully. The camera attached to the robot works effectively for monitoring the home even when the user is not at the site. Voice controlled automation proves to make the hexapod more user-friendly.

This work can be further improved by integrating it with more sensors like moisture sensor, temperature sensor, gas sensor to detect the moisture level in the soil to notify the user regarding watering plants, to automate turning on/off air coolers, and to notify users in case there is a gas leak. Machine learning algorithms can also be applied on the captured videos to identify faces and allow people inside the house.

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