International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-7, Issue-6, March 2019

Internet of Vehicles (IoV) Based Voice Controlled Autonomous Vehicle for Surveillance

Hans Tiwari, Ashish Jha, Vetrivelan. P

Abstract: ***Robotics and automated applications are usually found in big industrial plants that require repetitive human tasks. The places which do not have a suitable environment for human life, can be accessed by autonomous vehicles that are being controlled remotely with the help of controllers and sensors on them. These vehicles could be very valuable in different field such as military or industrial area. In this paper, a voice-controlled system for autonomous vehicle is proposed. This vehicle could help in reducing the work load and human effort in various tasks. The proposed system consists of an autonomous vehicle, which is controlled using specific voice commands defined for a particular action. The Alexa Voice Service application is used for giving voice commands. The proposed vehicle system was able to move forward, backward, left and right according to the input combination given to motor driver. A relay module and a motor driver are used to switch between different states of movement according to the commands received from user.***

Index Terms**: *Alexa Voice Service (AVS), ESP12e module, IFTTT, IoTs, IoVs, MQTT, Raspberry pi3.***

I. INTRODUCTION

There are many locations in the fields of industrial or military bases, which have conditions that are hazardous due to environmental or security constraints. These areas cannot be directly accessed by humans [1]. To overcome these problems, robots can be used as these can be made resistant to the known environmental conditions. The autonomous vehicle system proposed in present study is being controlled using Alexa voice service (AVS). This autonomous vehicle system is controlled through specific voice commands using AVS [2]. This service helps in accessing capabilities that are cloud-based with the help its APIs. The APIs convert the voice commands into text which then can be processed to do the respective task. Raspberry pi3 has been used as the development platform for this work. A developer account on the amazon website is needed to install the AVS on any platform.

Revised Manuscript Received on 30 March 2019.
***** Correspondence Author
Hans Tiwari*, B. Tech – Electronic and Computer Engineering in School of Electronics Engineering department, Vellore Institute of Technology, Chennai Campus, India.
Ashish Jha, B. Tech – Electronic and Computer Engineering in School of Electronics Engineering department, Vellore Institute of Technology, Chennai Campus, India.
Dr. Vetrivelan Pandu, Associate Professor and Programme Chair for Bachelor of Technology (Electronics and Communication Engineering) in School of Electronics Engineering at Vellore Institute of Technology (VIT), Chennai, India.

The open source AVS has been installed on the Raspberry pi3. The Raspberry pi3 has a USB mic connected to it which is used for giving voice commands as an input [3]. A speaker is connected to get the output of AVS. For general operational testing of the system and configuration of raspberry pi3, VNC (virtual network computing) viewer software has been used which enables to control the raspberry pi from a remote desktop (when both the pi and the computer are connected to the same internet connection). After the voice recognition is done on the AVS platform, it is sent to If This Then That (IFTTT), which is a free web-based service to create chains of simple conditional statements, called applets [4]. An applet is triggered by changes that occur within other web services such as ‘Amazon Alexa’. Once the command is received from the Alexa, it triggers the applet which makes changes to the connected services on that applet such as ‘Adafruit IO’. Once the applet on IFTTT is triggered it makes changes to the specific blocks created in the Adafruit IO platform. Adafruit IO is a simple internet service that smoothly enables different IoT devices to work with the received data. It is an ‘MQTT’ broker which uses MQTT protocol for communication. For viewing the data and controlling the devices, it provides a proper GUI interface as well. The blocks created on the Adafruit IO platform are connected using MQTT communication protocol to an ESP12e module [5]. A code written in C language is uploaded on this module using Arduino UNO software which enables it to work on publish-subscribe model. This module is placed on top of the autonomous vehicle to give analog or digital output according to the block created on the Adafruit IO platform. The autonomous vehicle is designed to work on the commands that are received on the ESP12e module. This vehicle consists of two 100 RPM BO motors which are controlled using L298 motor driver circuit board [6]. Three 9 Volt DC batteries are used as the power source for the motors. A two-channel 5V relay module with optocoupler is used to get the input from the ESP12e module for an output of 5V which is required by the motors to power and move the car accordingly. Different combinations of rotations of the motors can help in turning the vehicle towards left or right as well. The general block diagram for voice controlled autonomous vehicle system is shown in Figure 1. The autonomous vehicle is designed to work on the commands that are received on the ESP12e module. This vehicle consists of two 100 RPM BO motors which are controlled using L298 motor driver circuit board [6]. Three 9 Volt DC batteries are used as the power source for the motors.

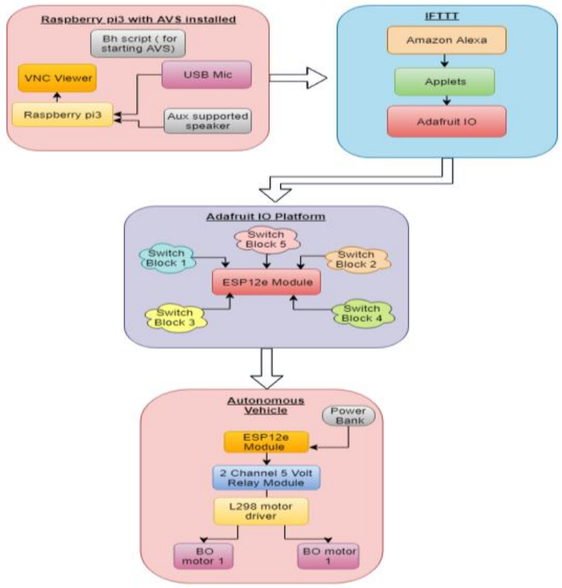


Figure 1. General block diagram for voice controlled autonomous vehicle system

Two-channel 5V relay modules with optocoupler is used to get the input from the ESP12e module for an output of 5V which is required by the motors to power and move the car accordingly. Different combinations of rotations of the motors can help in turning the vehicle towards left or right as well. The general block diagram for voice controlled autonomous vehicle system is shown in Figure 1.

II. RELATED WORK

Humayun Rashid et al. [1] presented the research of the designing & development of a voice controlled talking robot using mobile phone based on Arduino Uno microcontroller. The control system of the robot movement will be employed by the voice and the robot will response the commanding persons by generating sounds of human voice with each verbal instruction. The proposed system is designed based on microcontroller which is connected to smart android phone through Bluetooth module for receiving voice command. Dugan Um et al. [2], proposed a social robot missioned to autonomously capture images of people and feed multimedia contents to a social network or to a hospital for various social activities or for health monitoring purpose. Marius Branzila et al. [3] presented studies on development, implementation, testing and evaluation of an intelligent system for human-machine interaction by voice that allows a mobile robot to learn through a language based on voice commands. Dylan Kauling et al. [4] proposed the design and implementation of the system through the use of a Python client, a PHP and Flask Web Server/API, a Relational Database Management System (RDBMS) MySQL and external connections to services such as If This Then That (IFTTT). Ravi Kishore Kodali et al. [5] presented a paper, in which it is shown that communication between the low power ESP8266 Wi-Fi as client with the clients on smartphones and laptop using an MQTT protocol becomes easier and more reliable. Meng Wang et al. [6] proposed one single neuron PID control algorithm based on Elman neural network identification to optimize design of wheeled robot tracking system. Jih-Gau Juang et al. [7] presented a system for applying image-processing techniques and an intelligent control method to a wheeled mobile robot (WMR) for real-time trajectory recognition and tracking. Chan Zhen Yue et al. [8] presented an overall design for low-cost, microprocessor based smart home system designed for hall residents of Nanyang Technological University (as the main beneficiary). Sarthak Jai et al. [9] presented a paper which aims at designing a basic home automation application on Raspberry Pi through reading the subject of E-mail and the algorithm for the same has been developed in python environment which is the default programming environment provided by Raspberry Pi.

III. MATHEMATICAL MODEL

Hidden Markov Model

The main problem that is going to be addressed is the area classification on which the vehicle is going to traverse. The classification is going to be either navigable (Y) or non-navigable (N). This classification will be done with the help of Hidden Markov Model [11]. The model is defined as:

$$a_{ij} = P(q_{t+1} = s_j \mid q_t = s_i), 1 < i, j < N \qquad (1)$$

Where, N is the number of possible states in the model. Individual states are denoted and a specific state time as .M is the number of observation symbols per state. The observation corresponds to the output of the system being modeled. Individual symbols are denoted as A = is the state transition probability distribution.

$$b_j(k) = P(v_k^t \mid q_t = s_j), 1 < j < N, 1 < k < M \qquad (2)$$

The observation symbol probability distribution in state as shown in (2) where means the symbol at time. The initial state distribution where

$$\pi_i = P(q_1 = S_i), 1 < i < N \qquad (3)$$

$\lambda = (A, B, \pi)$ notation is used here. Given the observation sequence O and the model λ, HMM is used to compute optimal correspondence state sequence Q. The expression $P(Q \mid O, \lambda)$ is being maximized in the model. The main characteristics of navigable area (Y) is flat terrain and non-navigable area (N) is rough terrain. In flat terrain the points are well aligned with little variance in altitude and in rough terrain points are scattered without any proper alignment.

Forward Kinematics Model

Consider the 2-D kinematics of a robotic arm (4). The translational and rotational speeds can be expressed as

$$\begin{pmatrix} \dot{x} \\ \dot{y} \\ \omega \end{pmatrix} = \begin{pmatrix} \cos\theta & 1 & 0 \\ -\sin\theta & \cos\theta & 0 \\ -1 & 1 & 1 \end{pmatrix} \begin{pmatrix} v \\ 0 \\ \omega_0 \end{pmatrix} \qquad (4)$$

Where, ẋ and ẏ are the coordinates of the center of mass of the platform, be the angle between heading direction and the axis specifying the orientation of the local platform with respect to the inertial frame. and are the linear and angular speed of the autonomous vehicle. For given relative configuration of each pair of adjacent links of a robot, the forward kinematics determines the configuration of the end-effector, such as the gripper or tool mounted at the end of the robot. In open chain manipulators attached to the autonomous vehicle, the links form a single serial chain and each pair of links is connected either by revolute joint or by prismatic joint. For revolute joints, the revolute variable is given by an angle where the angle is equated to angle 0. All joint angles are measured using a right-handed coordinate system so that angle is considered positive if it is clockwise as viewed along the direction of axis. Prismatic joints are described by a linear displacement along a directed axis where positive displacement is chosen along the axis. The forward kinematic map of an open chain manipulator is constructed by composing the rigid motions due to individual joints as detailed in [12].

IV. VOICE CONTROLLED AUTONOMOUS VEHICLE FOR SURVEILLANCE

The devices used in present system are raspberry pi3, ESP12e module, two-channel 5V relay module, L298 motor driver circuit board and two 100 RPM BO motors. In the raspberry pi3, Raspbian OS has been installed that is called 'Stretch'. This OS simplifies the procedure of installing AVS on the raspberry pi3. Once the AVS is installed, a USB Mic and a portable aux supported speaker are connected to the raspberry pi3. Running a small sh script on the Stretch OS starts the Alexa voice service and then the corresponding commands are fed as voice input to the AVS. Specific triggers are made on the IFTTT server to trigger the applets. Many applets have been deployed for triggering the blocks on the Adafruit IO platform for the movements of the autonomous vehicle. The algorithmic diagram of the proposed autonomous vehicle can be seen in Figure 4.

These applets once triggered by amazon alexa using specific voice commands, such as "ALEXA TRIGGER MOVE FORWARD" (for moving the vehicle forward), send the commands directly to the blocks of Adafruit IO platform. Each block created on the platform is connected to two applets on the IFTTT server, which either turn the block "ON" by sending a "1" or turn it "OFF" by sending a "0". All the voice commands with corresponding actions have been shown in Table 1. The adafruit IO platform blocks send the command on the ESP12e module, which requires internet access to receive the commands from Adafruit IO. The ESP12e module is a type of a Wi-Fi module which has ability to connect to the nearby Wi-Fi for given security credentials. To make the ESP12e module work, a code on using Arduino UNO software is uploaded on it. The code contains Wi-Fi credentials and AIO key which helps in connecting to the Adafruit account that the key belongs to. The code is in C language with all the libraries for ESP12e module and Adafruit MQTT. The Wi-Fi credentials contain SSID and password of the network which it is connected to. The setup and main functions contain the method of MQTT (Message Queue Telemetry Transport) protocol to receive commands from Adafruit IO platform. The ESP12e module is being powered using an onboard power bank. The two digital outputs received from ESP12e module are again fed to a 5V two-channel relay which switches its output between the two states in order to drive the motor forward or backward through motor driver. The movement of motors in different directions is controlled using a L298 motor driver which is a dual full bridge driver. L298 motor driver (H-Bridge) is able to control two different DC motors simultaneously. Three 9V DC batteries are used as power supply for the motors. The whole setup consisting of motor driver, relay module, Wi-Fi module and batteries is placed on chassis of the vehicle.

Table. 1. Voice commands and their actions

Voice command	Motor 1	Motor 2	Action
Alexa trigger move forward.	Anti-Clockwise	Clockwise	Moves the vehicle forward
Alexa trigger move backward.	Clockwise	Anti-Clockwise	Moves the vehicle backward.
Alexa trigger turn left.	Clockwise	Clockwise	Turns the vehicle left.
Alexa trigger turn right.	Anti-Clockwise	Anti-Clockwise	Turns the vehicle right.
Alexa trigger stop.	No rotation	No rotation	Stops the vehicle.

Pseudocode

Voice Controlled Autonomous Vehicle System for Surveillance

- Receive Voice Commands from USB Mic.
- If (Voice Commands is correct)
- then Trigger IFTTT applet.
- else
- Return Trigger does not exist
- Based on applet Triggered change the Switch Position on Adafruit IO
- If (ESP12e is connected to Internet)
- then Update the Change on Module
- else change in not updated

Vehicle Movement Control

- Receive input from ESP12e module and transfers it to Two Channel 5V Relay Module
- If (forward output enabled)
- then Motor 1 rotates anticlockwise & Motor 2 rotates clockwise i.e. Vehicle Moves Forward
- else if (backward output enabled)
- then Motor 1 rotates clockwise & Motor 2 rotates anticlockwise i.e. Vehicle Moves Backward
- If (moving Right output enabled)

- then Motor 1 rotates anticlockwise & Motor 2 rotates anticlockwise i.e. Vehicle Moves Right
- If (moving Left output enabled)
- then Motor 1 rotates clockwise & Motor 2 rotates clockwise i.e. Vehicle Moves Left
- else
- Both Motors stops i.e. Vehicle Stops

V. IMPLEMENTATION

Present section contains explanation of the algorithmic flow in two parts. The first part contains full flow from AVS to the autonomous vehicle and second part contains the working of different components placed on the chassis of the vehicle.

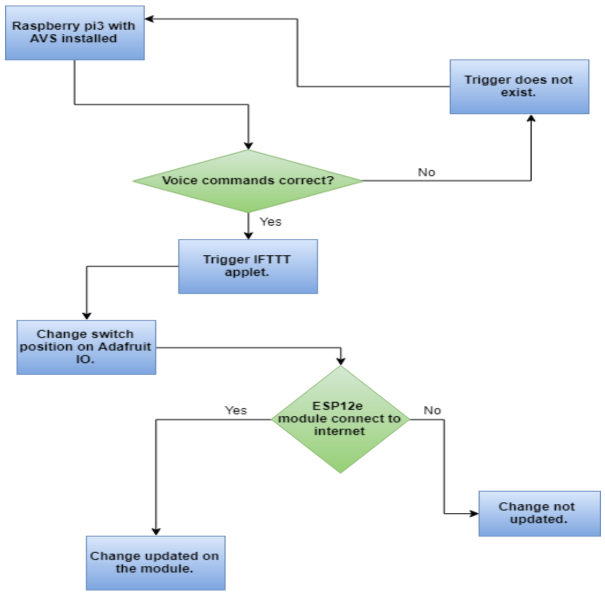


Figure 2. IFTTT and Adafruit IO Algorithmic Flow

First part of the algorithmic flow starts with voice commands input given to the AVS installed on raspberry pi3. If the voice commands are valid, these trigger the IFTTT applet else "Alexa" gives output from the aux supported speaker connected to the raspberry pi3 saying that the IFTTT trigger does not exist. Once the applet is triggered, it changes position of the respective switch block on the Adafruit IO platform. If ESP12e module is connected to the internet, the changes are updated from Adafruit IO to the module else the changes are not updated. The algorithmic flow can be seen in Figure 2.

Second part of the algorithmic flow focuses on the working of the vehicle is shown in Figure 3. The ESP12e module receives the commands from adafruit IO and then the two-channel 5V relay module gets power to switch its output between different states. This then triggers different combinations of the L298 motor driver circuit board based on the circuit designed. The movement on the car depends on the output that is enabled from the switch block on adafruit IO. As shown in the algorithmic flow (Figure 3), different outputs when enabled turn both the motors connected to the wheels accordingly. For example, if the 'forward' output is enabled, "motor 1" rotates anti-clockwise and "motor 2" rotates clockwise which results in moving the vehicle forward.

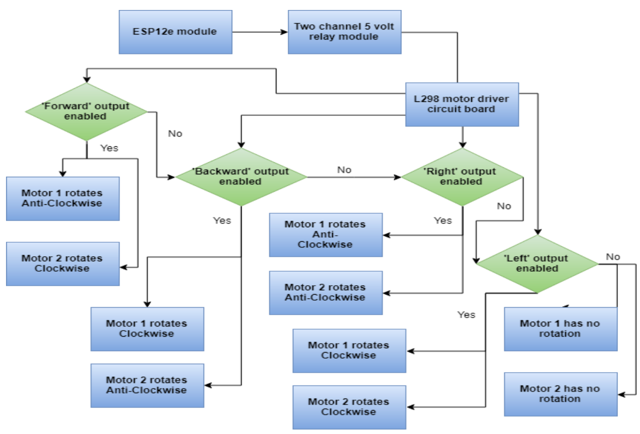


Figure 3. Voice Controlled IoV based Autonomous Vehicle

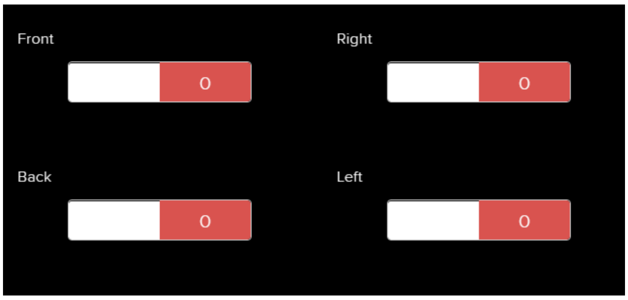
VI. RESULT AND DISCUSSION

By starting the "sh" script on the raspberry pi3 to enable Alexa and speak in the USB mic, the vehicle makes its movement according the voice commands as shown in Table 1. The vehicle is able to move forward, backward, left and right according to the input combination given to L298 motor driver from the two-channel relay module which gives output according to the commands received from user.

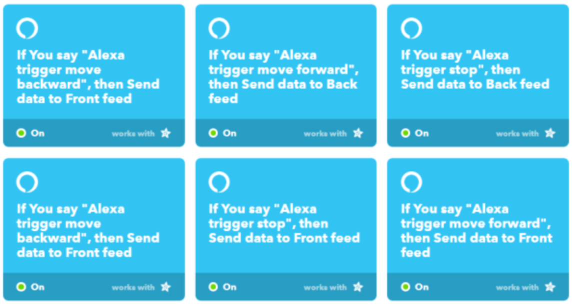
If the command "Alexa trigger stop" is given, both the motors stop their rotation causing the vehicle to stop; and on similar lines all the other voice commands work as well. All the commands work in real-time, which means the response of the vehicle is normally very quick. The Adafruit IO platform switch blocks and IFTTT applets is shown on Figure 4.

VII. CONCLUSION

This paper presents a new technique for controlling an autonomous vehicle through voice commands. Voice commands are recognized via AVS. The vehicle is easily able to recognize the voice commands and respond accordingly. The applets created in IFTTT are connected to ESP12e module, through Adafruit IO. The vehicle works in any range as long as the ESP12e module is connected to a Wi-Fi for internet access so that it can receive input signal from the Adafruit IO platform. The motors are controlled by signals received from ESP12e module, which is mounted on the vehicle. The vehicle circuitry uses two channel relay module and a motor driver to control the movements.



(a)



(b)

Figure 4. (a) Adafruit IO switch blocks

(b) IFTTT applets

VIII. FUTURE WORKS

The work can be extended to make this vehicle more useful by incorporating more voice commands which can be used for respective purposes. A power optimization technique could be used to increase the life of the batteries attached. A camera can be attached for full view of the scene at which this vehicle would be deployed. A GPS could be attached on this vehicle for tracking where it goes on the map to reduce the chances of losing it if in case the camera stops working. Artificial intelligence can be incorporated so that the robot is enabled to interact more appropriately by analyzing the behavior of users and the characteristics of testing environment.

REFERENCES

1. Rashid, Humayun & Ahmed, Iftekhar & Bin Osman, Sayed & Rasheduzzaman, Md & Newaz, Qader & Reza, Sharif, “Design and Implementation of a Voice Controlled Robot with Human Interaction Ability”, International Conference on Computer, Communication, Chemical, Materials and Electronic Engineering (IC4ME2-2017).
2. Dugan Um, Jangwoon Park, Jeongsik Shin, and Woo Ho Lee, “A Social Robot, “Dali,” for Aging in Place Technology,” Journal of Robotics, vol. 2018, Article ID 6739652, 10 pages, 2018.
3. Branzila, Marius & Sărmăşanu, Constantin & Fanaru, Gabriel. (2014). ROBOTVOICE - Voice command of a robot. EPE 2014 - Proceedings of the 2014 International Conference and Exposition on Electrical and Power Engineering, 2014
4. D. Kauling and Q. H. Mahmoud, "Sensorian Hub: An IFTTT-based platform for collecting and processing sensor data," 2017 14th IEEE Annual Consumer Communications & Networking Conference (CCNC), Las Vegas, NV, 2017, pp. 504-509.
5. R. K. Kodali and K. S. Mahesh, "A low cost implementation of MQTT using ESP8266," 2016 2nd International Conference on Contemporary Computing and Informatics (IC3I), Noida, 2016, pp. 404-408.
6. Meng Wang and Wuyin Jin, "The optimal design of wheeled robot tracking system," 2016 2nd IEEE International Conference on Computer and Communications (ICCC), Chengdu, 2016, pp. 900-906.
7. Jih-Gau Juang, Ko-Jui Hsu and Chih-Min Lin, “A wheeled mobile robot path-tracking system based on image processing and adaptive CMAC”, Journal of Marine Science and Technology, Vol. 22, No. 3, pp. 331-340 (2014).
8. C. Z. Yue and S. Ping, "Voice activated smart home design and implementation," 2017 2nd International Conference on Frontiers of Sensors Technologies (ICFST), Shenzhen, 2017, pp. 489-492.
9. S. Jain, A. Vaibhav and L. Goyal, "Raspberry Pi based interactive home automation system through E-mail," 2014 International Conference on Reliability Optimization and Information Technology (ICROIT), Faridabad, 2014, pp. 277-280.
10. D. F. Wolf, G. S. Sukhatme, D. Fox and W. Burgard, “Autonomous Terrain Mapping and Classification Using Hidden Markov Models," Proceedings of the 2005 IEEE International Conference on Robotics and Automation, Barcelona, Spain, 2005, pp. 2026-2031.
11. Murray Richard M., Zexiang Li, Shankar Sastry, S, “A mathematical introduction to robotic manipulation: Chapter 3”, CRC Press, 1994.
12. Sreenivas Tejomurtula; Subhash Kak, “Inverse kinematics in robotics using neural networks”, Information Sciences, ISSN: 0020-0255, Vol: 116, Issue: 2, Page: 147-164,1999.

AUTHORS PROFILE

Hans Tiwari, Student [hans.tiwari@gmail.com], is pursuing B. Tech – Electronic and Computer Engineering in School of Electronics Engineering department, Vellore Institute of Technology, Chennai Campus, India. His research interest includes Machine learning, IoT, AR/VR.

Ashish Jha, Student [jhaashish3026@gmail.com], is pursuing B. Tech – Electronic and Computer Engineering in School of Electronics Engineering department, Vellore Institute of Technology, Chennai Campus, India. His research interest includes Wireless sensor Networks, IoT, AR/VR.

Dr. Vetrivelan Pandu, PhD [vetrivelansir@gmail.com], is an Associate Professor and Programme Chair for Bachelor of Technology (Electronics and Communication Engineering) in School of Electronics Engineering at Vellore Institute of Technology (VIT), Chennai, India. He has completed Bachelor of Engineering from the University of Madras, Chennai and both Master of Engineering in Embedded Systems Technologies and Doctor of Philosophy in Information and Communication Engineering from Anna University, Chennai. He has 14.7 years of teaching experience altogether in CSE and ECE Departments in both private Engineering Colleges in Chennai (affiliated to Anna University, Chennai) and Private Engineering University in Chennai respectively. He has authored 3 book chapters and one proceeding in lecture notes published by reputed springer publisher, and has authored 25+ Scopus indexed Journal papers and few other papers published in reputed international conferences. He has served as member in Board of Studies, doctoral committee, doctoral thesis Examiner, doctoral oral Examiner in both private and government Universities. He has also served as reviewer for reputed International Journals and International Conferences. His research interests include Wireless Networks, Adhoc and Sensor Networks, VANETs, Embedded Systems and Internet of Things (IoT) with Machine Learning.