JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

The Internet of Things Based Voice-Control for Semi-Autonomous Robot

Rajiv Dey[1], Dhruv Aditya Mittal[2], Pankaj Sahu
School of Engineering and Technology, BML Munjal University, Gurugram, India
[1]rajeevdey0000@gmail.com, [2]dhruvadityamittal@gmail.com, pankaj.sahu.19pd@bmu.edu.in

***Abstract*— Since the inception of the idea of automation, robotics have come a long way and have offered humans the capability to do the undoable, predict the unpredictable and perform the un-performable. Recently, the internet has become the most popular medium for interconnecting different physical things that are located at remote locations. It is also named the internet of things (IoT) which is developing technology and is mostly used for data transfer between a large numbers of uniquely addressable devices. This paper develops a semi-autonomous voice controlled robotic framework using an open-source cloud platform and a publicly accessible voice recognition smartphone assistant i.e. Google voice assistant and develops an IoT-based application. The robotic vehicle in the proposed framework receives linguistic voice commands from a smartphone via Google voice assistance application and uses the genetic algorithm based controller to decode the meaning of linguistic voice commands and control the vehicle's driving speed more realistically. The proposed system is implemented on the NVIS 3302ARD hardware platform, and the experimental results show its efficacy. Furthermore, unlike relay-based methods, the proposed systems do not cause jitter and electromagnetic disruptions in embedded hardware, which could lead to systolic failure.**

Keywords*— Voice activated robot; internet of things (IoT); mobile robot.

I. INTRODUCTION

Robot is as integral part of modern civilization that has found its extensive applications in smart manufacturing, smart healthcare, smart household operation, mining, laboratory research, bomb disposal, etc. The robot is a programmable machine that primarily removes human intervention in performing repetitive actions and dangerous tasks. The structure of a robot tries to replicate human and animal behavior having a movable physical structure embedded with sensors and actuators. A robot differs from an ordinary machine with its inside controlling mechanism that make the robot move around safely and perform the specified task effectively [1]. To make a robot super-versatile and user friendly, the control parameters need to be set within pre-defined boundaries to achieve close-loop stability in the system. The conventional robotic control is PID based having on-site adjustment facility using verity of tuning rules [2-4]. However, in real word applications, the highly non-linear dynamics of the robotic system associated with huge uncertainties encourages to implement adaptive control mechanism [5]. To achieve high-degree of precision and accuracy via intelligent control, the artificial intelligence (AI) techniques has a significant role; the algorithms like Fuzzy logic, GA, PSO, neural network, etc. are used for robotic control for various robotic applications [6-13].

With a coordinated man-machine interface, a robot can performs various complex task on real time basis; the control of robot is being carried out via pendant buttons, joy sticks, typing command string using keyboard, etc. However, in this operation, the chance of mistake is large and always requires extremely trained operators. With development of speech recognition and natural language processing techniques, the voice activated robots are came in to existence that are being operational by only giving voice commands [14]. The natural spoken-language-based man-machine interface allows hands-free operation of robots via a semi-trained operators. A sound controlled apparatus has been developed for controlling robot that can process number of space separated words [15]. Chatterjee et al. has proposed a particle swarm optimization based voice controlled robotic vehicle which recognizes the voice commands using neural network and take the decisions of its movement using Fuzzy logic [16]. However, it is a wire-controlled mechanism that is being operated in a closed area of $1m^2$ and velocity limited within 0.008m/s. In [17], a robotic navigation mechanism has been proposed that recognizes some specific isolated words where the external noise are being filtered out using on-bard DSP processor. Munasinghe et al. have reported a technique for converting voice signal acquired from a microphone into useful digital commands using linear predictive coding (LPC) [18].

The next stage of innovation is smart implementation of robot by controlling it from remote location. The smart robotic control can be achieve via the Internet of things (IoT) technology where the Internet is extended up to the sensors and actuators of the robot. The basic aim of IoT is to link the unconnected objects to the internet so as to enable them communicate share information with the people and other objects [2 19]. The information collected from these physical objects are further analyzed and used to make the system more smart and mobile to be able to control remotely. Moreover, with the ease in interaction between a variety of objects such as sensors, actuators, mobile phones, vehicles, garage doors, home appliances etc., will facilitate the development of a large number of IoT applications in a variety of domains e.g. robotic applications, health care monitoring, home automation, industrial automation, smart grid etc. According to the latest survey conducted by ABI research shows that currently 10 billion devices are connected to the internet and this number will increase to 30 billion by 2020 [1 20]. The IoT based controlling of home appliances is discussed in [21]. The Internet of robotic things (IoRT) concept has been introduced for IoT based robotic control where the sensor data acquired from the robot is being analyzed and subsequent command for actuator has been generated remotely via the Internet [22]. A cloud based robot for assisting elderly people has been proposed in [23]. An IoT based family robot is presented in [24]. Oh et. al. has proposed a rule-based context transforming model to extract situational information from each context information in IoT environment [25]. Solorio et. al has demonstrated a IoT based voice-activated robot for domestic applications [26]. The entire hardware is fitted on a lawnmower as a base along with a Wi-Fi module and ultrasonic obstacle avoidance sensor that is being controlled using voice command via cloud. The voice commands are captured via internet enabled speaker e.g. Amazon Alexa, that converts the speech into text and uploads to the cloud. The robot continuously receives the decoded signals from the cloud and acts accordingly. The robot can understand only crisp commands and operates only on five different predefined speeds. However, in real life, the voice commands spoken by human are vague in nature i.e. same linguistic word may have different meaning for different situations. The robotic vehicle presented in this work does not have the capability to differentiate between spoken linguistic variables e.g. fast, very fast etc. and it is not able to utilize the human reasoning and thinking to take its own decision for generation of commands to the actuator for controlling its speed. In the proposed paper the desired speed of the robot is determined using genetic algorithm based approach. Since, the proposed vehicle has been developed for indoor application using a Wi-Fi module in the vehicle, it cannot be controlled if the radial distance from ground-control station exceeds 50 meters.

This paper has proposed an IoT based voice-activated semi-autonomous robot. The major contributions of the paper are listed below:

i. Distributed computing based approach e.g. the linguistic voice command to text conversion is done on a Google voice assistance application running on the cell phone, decoding of the text to commands which has to be further sent to the robot is done at the cloud. The received linguistic commands at the robot is decoded using algorithm running on the embedded hardware for generation of motor control commands of robot
ii. Enhanced coverage range of robot i.e. 1 Km for indoor applications using low powered long range 2.4 GHz RF transreciever module NRF24L01 for last-mile link between ground control station and robot.
iii. As the robot velocity is modulated according to the spoken linguistic command therefore, it consumes less battery power.

The proposed robot will find its extensive applications as floor washing vehicles in railways, lawn mower robots, indoor transportation system, etc. A prototype of the proposed robot has made and tested. Organization of this paper is as follows: the methodology for proposed system given in Section-II that includes the implemented IoT model and detail description of hardware and software used in the proposed system. In Section-III, result analysis are provided and the Section-IV concludes the paper.

II. METHODILOGY FOR THE PROPOSED SYSTEM

A. IoT model for control flow: In the proposed system architecture as shown in Fig. 1, the voice commands were given to the robotic vehicle using Google assistance application running on a cell phone. Alternatively, the voice commands can also be sent using Google home with internet enabled speaker. The Google assistance application basically converts the voice commands into text statements and upload it to a cloud server e.g. IFTTT (if this then that). The IFTTT is a free cloud based service that allows users to create their own customized conditional statements also known as applets. The Google assistance application provides instructions to IFTTT server to trigger the applets as shown in Fig. 2. Once the applet gets triggered it sends commands to the Adafruit server which further reciprocate it to the ground-control station. It continuously search for the new commands from the cloud and the received commands are further transmitted to the controller fitted in the robot using a long range low power RF transreciever NRF24L01. This received signal acts as an input to the algorithm running on the controller. In the proposed work,

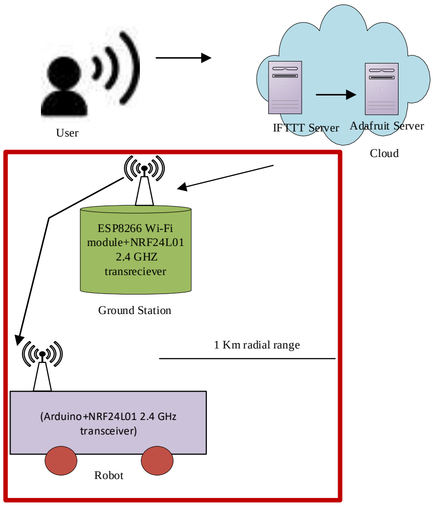

Fig 1. Block diagram representation of the proposed architecture.

robot motion control algorithm is only used to generate speed control signals of the robot and its direction control decisions are independently taken by the controller itself.

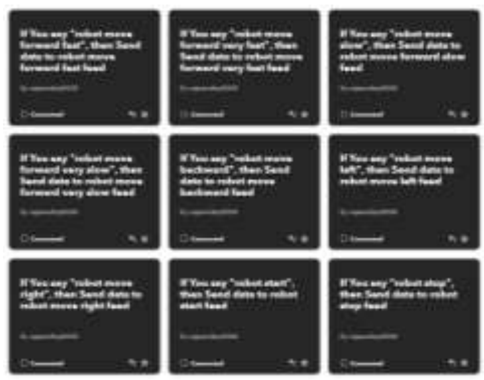

Fig 2. Voice command apples.

B. Hardware and software descriptions: To demonstrate the effective functioning of the proposed system, a robo car base from Nvis as shown in Fig. 3 has been used. It is driven by a 12v DC, 1A rechargeable battery and the entire package has two 6v, 100 rpm dc motors with inbuilt Hall Effect encoders for measuring the wheel velocity, an ultrasonic sensor module for obstacle detection, and an ATMega328 microcontroller based development board which Arduino IDE compatible. A low power long range RF transreciever

NRF24L01 is externally connected to the development board which supports 1Km line of sight communication. The voice commands were given on a smart phone having installed Google voice assistance application, it's a freeware mobile application software that converts the spoken voice commands into text and then upload it to the cloud as already discussed above in Section-II. For direction and speed control of the robot a 5-35V DC, 2 A L298N motor driver shield has been used as shown in Fig. 4.

Fig. 3. Representation of NVIS robotic platform.

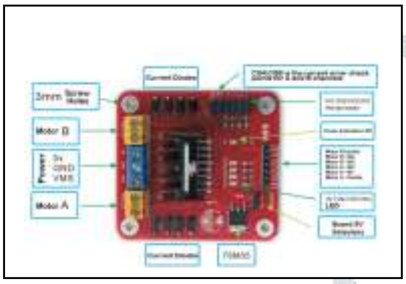

Fig. 4. Representation of DC motor driver.

Table 1: Supported Commands

S.No	Instructions to Google Assistance
1	Robot move forward very fast
2	Robot move forward fast
3	Robot move forward very slow
4	Robot move forward slow
5	Robot move backward
7	Robot move left
8	Robot move right
9	Robot stop

At each sampling instant the desired velocity of the robot is calculated from the expert knowledge base and it is mathematically represented as

$$Desired\ velocity = Significance\ (velocity\ fraction) obtianed\ from\ genetic\ algorithm \times current\ velocity\ of\ robot\ , \quad (1)$$

and error $e = desired\ velocity - actual\ velocity.$

Genetic algorithmic model has been used to compute the PWM values of motor driver in order to control the robot speed. The having two inputs namely desired velocity, measured velocity, and one PWM output. The robot will have zero velocity only when robot stop command is spoken. The voice

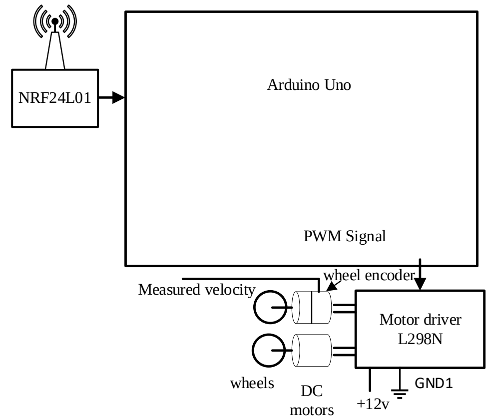

Fig. 5. Block diagram representation of robot

instructions used are shown in Table 1.

III. Results and Discussion

The block diagram representation of the proposed robot is shown in Fig. 5. In Fig. 5, it can be seen that the radio frequency signals are coming from the central station are received via RF trans-receiver NRF24L01. The voice commands are basically decoded using genetic algorithm running inside the microcontroller and the PWM signals for controlling the speed of the robot motors are generated from the PWM channels of the microcontroller development board. The output performance of the proposed robot can be seen in

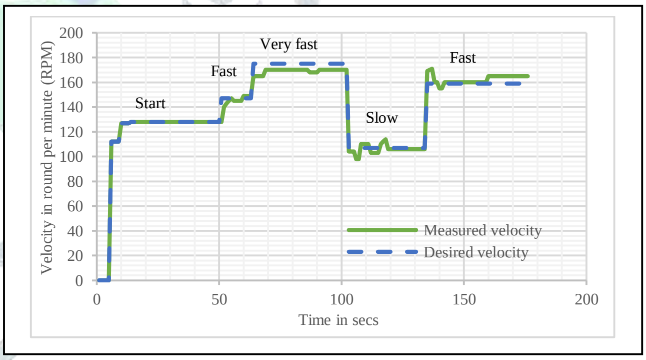

Fig. 6. Output speed of the proposed robot.

IV. Conclusion

In this paper an internet of things based semi-autonomous voice control robot has been demonstrated where the robot has the capability to take decisions based on the human understandable linguistic commands. For different linguistic commands the desired velocity has been calculated using genetic algorithm and experimental results shows that the measured velocity tracks the desired velocity accurately. Through experimental results it has been shown.. By the inculcation of the internet of things the robot can be controlled from anywhere in the world were the internet capability is available. The robot can be used in the indoor applications within a range of 1 KM line of sight.

References:

[1] https://science.howstuffworks.com/robot.html

[2] P. Tomei, "Adaptive PD controller for robot manipulators", IEEE Transactions on Robotics and Automation, Vol. 7(4), pp. 565-570, 1991.

[3] S. Bouabdallah, A. Noth, R. Siegwart, “PID vs LQ control techniques applied to an indoor micro quadrotor”, IEEE International Conference on Intelligent Robots and Systems, 2004.

[4] E. Jafarov, M. Parlakci, Y. Istefanopulos, “A new variable structure PID-controller design for robot manipulators”, IEEE Transactions on Control Systems Technology, Vol. 13 (1), pp. 122-130, 2005.

[5] Huang, An-Chyau, Chin, Ming-Chih. 2010. Adaptive Control of Robot Manipulator. -11

[6] H.A. Malki, D. Misir, D. Feigenspan, G. Chen, “Fuzzy PID control of a flexible-joint robot arm with uncertainties from time-varying loads”, IEEE Transactions on Control Systems Technology, Vol. 5(3), pp. 371-378, 1997.

[7] K. Kiguchi, T. Tanaka, T. Fukuda, “Neuro-fuzzy control of a robotic exoskeleton with EMG signals”, IEEE Transactions on Fuzzy Systems, Vol.12(4), pp. 481 – 490, 2004.

[8] M. Ju, C. Lin, D. Lin, I. Hwang, S. Chen, “A rehabilitation robot with force-position hybrid fuzzy controller: hybrid fuzzy control of rehabilitation robot”, IEEE Transactions on Neural Systems and Rehabilitation Engineering, Vol. 13(3) , pp. 349 – 358, 2005.

[9] T. Das, I. Kar, “Design and implementation of an adaptive fuzzy logic-based controller for wheeled mobile robots”, IEEE Transactions on Control Systems Technology, Vol. 14 (3), pp. 501-510, 2006.

[10] Z. Bingül, O.Karahan, “A Fuzzy Logic Controller tuned with PSO for 2 DOF robot trajectory control”, Elsevier Journal of expert systems with applications,

Vol. 38 (1), pp. 1017-1031, 2011

[11] K. Das Sharma, A. Chatterjee, A. Rakshit, “A PSO–Lyapunov hybrid stable adaptive fuzzy tracking control approach for vision-based robot navigation”, IEEE Transactions on Instrumentation and Measurement, Vol. 61(7), pp. 1908-1914, 2012.

[12] W. He, Y. Chen, Z. Yin, “Adaptive neural network control of an uncertain robot with full-state constraints”, IEEE Transactions on Cybernetics, Vol. 46(3), pp. 620-629, 2016.

[13] H. Fenga, C. Yina, W. Wenga, W. Maa, J. Zhoua, W. Jiaab, Z. Zhanga, “Robotic excavator trajectory control using an improved GA based PID controller”, Elsevier journal of mechanical systems and signal processing, Volume 105, pp. 153-168, 2018.

[14] D.P.Mital, G.W.Leng, “A voice-activated robot with artificial intelligence”, Robotics and Autonomous Systems, vol. 4 (4), pp. 339-344, 1989.

[15] “Sound controlleble apparatus perticularly useful in controlling toys and robot” US patent no. 5209695, 1993.

[16] A. Chatterjee, K. Pulasinghe, K. Watanabe, K. Izumi, “A particle-swarm-optimized fuzzy-neural network for voice-controlled robot systems”, *IEEE Transactions on Industrial Electronics*, Vol. 52(6), pp. 1478-1489, 2005.

[17] H. Heidaria, S. Gobeeb, “Isolated Word Command Recognition for Robot Navigation”, International Symposium on Robotics and Intelligent Sensors 2012, pp. 412 – 419.

[18] Munasinghe, R. Voice Controlled Robot. Report [Online]. Available: https://pdfs.semanticscholar.org/e64b/50f5fadf68dcc57975bda967c0ca9df036ca.pdf Accessed: Jan 23-2018

[19] Daradkeh, Y., Namiot, D., & Sneps-Sneppe, M. (2012). M2M standards: possible extensions for open API from ETSI. *European Journal of Scientific Research*, *72*(4), 628-637.

[20] Dudeja, K., & Kharabanda, (2014), “A. Voice Controlled Robot”. Journal of The International Association of Advanced Technology and Science. Vol. 15, September 2014, ISSN-3347-4482.

[21] D. Pavithra, R Balakrishnan, “IoT based monitoring and control system for home automation”, IEEE Global Conference on Communication Technologies, 2015, pp.169-173.

[22] P. Simoens et.al., “Internet of robotic things: context-aware and personalized interventions of assistive social robots”, 5th IEEE International Conference on Cloud Networking, Pisa, Italy, 2016.

[23] M. Bonaccorsi et al., “Design of cloud robotic services for senior citizens to improve independent living and personal health management,” in Ambient Assisted Living. Springer, 2015, pp. 465–475.

[24] X. Li, X. Ding, U. Zanhng, Z Sun, H Zhao, “IoT family robot based on Raspberry Pi”, IEEE International Conference on Information System and Artificial Intelligence, 2016, pp. 622-625.

[25] J. Oh, Y. Park, J. Choi, J. Choi, “A rule-based context transforming model for robot services in internet of things environment”, IEEE 14th International Conference on Ubiquitous Robots and Ambient Intelligence, pp. 331-336, 2017

[26] J. A. Solorio, J. M. Garcia-Bravo, and B. A. Newell, “Voice activated semi-autonomous vehicle using off the shelf home automation hardware”, IEEE journal of internet of things, vol 5 (6), pp. 5046-54, 2018.