

# INTERACTIVE ASSISTANT ROBOT FOR INDOOR NAVIGATION

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*Abstract-* Technology has massively transformed in the past few decades, from being a desktop personal computer to handheld mobile phones, with increasing raw computing power consuming lesser energy. This computability is now not just isolated to a single device, but integrated with other devices as well. This paradigm was first observed with the advent of cloud services in Cyber-physical systems. The evolution of Artificial Intelligence(AI) with cloud computing and the important of this field in human life, induce us to make simple and efficient talkative assistant robot for indoor navigation. The navigation system in outdoor typically rely upon Global Positioning System (GPS) but the indoor navigation systems have to rely upon different technologies, as GPS signals cannot be received indoors. Thus, several technologies have been proposed and implemented over the past decade to improve navigation in indoors. But they were costly and less effective. Therefore, we have proposed a system that assist humans to find their location in a conversational manner. The proposed system has built by bringing the benefits of a personal assistant device, Amazon Alexa, Amazon's cloud services and its speech services for navigating people in indoors. A Raspberry Pi 3 Model B is used as the hardware component for providing smart features for our system. The voice service can be triggered using the keyword "Alexa". The skill/application that we have developed can be triggered using the voice command. Once Alexa is triggered, it runs a script on the cloud, which in-turn runs a subroutine on the Raspberry Pi 3 for providing route for that particular location. Once computation is done in the Raspberry Pi, it sends the text back to Alexa. Alexa converts that text to voice and tells the route to user.

## I. INTRODUCTION

Technology is a constantly developing and changing aspect of learning. The ability of a system to calculate, reason, perceive relationships and analogies, learn from experience, store and retrieve information from memory, solve problems, comprehend complex ideas, use natural language fluently, classify, generalize, and adapt new situations is called an intelligence. One of the types of Intelligence is Artificial Intelligence (AI) and is the branch of computer Science concerned with making computers behave like humans. According to the father of Artificial Intelligence, John McCarthy, it is "The science and engineering of making intelligent machines, especially intelligent computer programs". AI is accomplished by studying how human

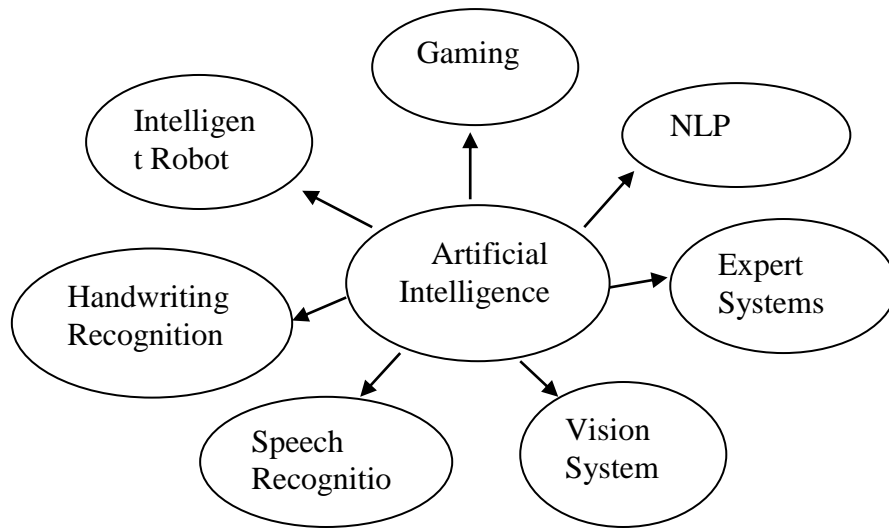
brain thinks and how humans learn, decide, and work while trying to solve a problem, and then using the outcomes of this study as a basis of developing intelligent software and systems. The two major needs of AI, first to Create Expert Systems – the systems which exhibit intelligent behaviour, learn, demonstrate, explain, and advice its users and next to implement Human Intelligence in Machines – Creating systems that understand, think, learn, and behave like humans. A major thrust of AI is in the development of computer functions associated with human intelligence, such as reasoning, learning, and problem solving. The various dominant fields of AI are listed in Fig 1. The field of AI work culminated in the invention of the Programmable Digital Computer in the 1940s, a machine based on the abstract essence of mathematical reasoning. In the later years one of the important goals of AI research is to allow computers to communicate in natural languages like English. Natural Language Processing (NLP) refers to AI method of communicating with an intelligent system using a natural language such as English. Processing of Natural Language is required when you want an intelligent system like robot to perform as per your instructions, when you want to hear decision from a dialogue based clinical expert system, etc. NLP consists of two components. One is Natural Language Understanding (NLU) used to map the given input in natural language into useful representations and to analyse different aspects of the language. Other is Natural Language Generation (NLG) used for the process of producing meaningful phrases and sentences in the form of natural language from some internal representation. A new paradigm called "intelligent agents" became widely accepted during the 90s. An intelligent agent is a system that perceives its environment and takes actions which maximize its chances of success. In the first decades of 21st century, language processing engines with intelligent agent powered by smart search engines can easily beat humans at answering general trivia questions. Indoor navigation is a very active research field due to its large number of possible applications. With a smart phone in hand, it is easy to find our way to a destination even in an unfamiliar city. However, it is still easy to get lost indoors, where Global Positioning System (GPS) signals are not accurately traceable because microwaves will be attenuated and

scattered by roofs, walls and other objects. The field of computing is undergoing a fundamental transformation in indoor navigation. Cloud Computing is enabling new ways of storing, handling and processing even larger quantities of data, as well as new intelligent algorithms, applications and experiences.

## II. LITERATURE SURVEY

Wong Joanne, Sanna Taking, Nazrin Isa and Kok Chao<sup>1</sup> proposed an application that tracks indoor positioning, because using GPS in indoor navigation results in signal loss due to the contact of building walls. This system works with variable Wi-Fi access points available in smart phones and buildings. This system greatly reduces power consumption and complexity and also maintains accuracy and speed. Seema Rawat, Parv Gupta and Praveen Kumar<sup>2</sup> designed a system using Automatic Speech Recognition (ASR). This system briefly describes its working, types, overview, history, future aspects and scopes. One of the trending applications of Artificial Intelligence is ASR. It is the voice respondent system in mobile application and helps in the lives of blind, deaf and physically challenged peoples. A.Ramya and T.Srihari<sup>3</sup> proposed a model that controls various domestic appliances through the application of Raspberry pi through voice programmed by Python language. Dynamic Time Warping (DTW) recognizes the voice of the user. Raspberry pi is used to save energy, provides safety to home, elder and disabled people can access this easily. Abhiram T.S, Arya A.R, Aswin R.S and Jeena John<sup>4</sup> proposed a model that mainly focuses on home automation with Artificial Intelligence thereby developing self-thinking home. This model uses Voice Recognition System and in this model if the number of words reduces, accuracy gets increased. Raghvendra Priyam, Rashmi Kumari, and Dr. Prof Videh Kishori Thakur<sup>5</sup> proposed a system that uses speech recognition technology with Artificial Intelligence because using this user can do other works simultaneously and can control appliances by voice input. This system uses four different speech enhancement algorithms to effectively control the machinery through voice. Jatin Borano<sup>6</sup> reviewed the current progress of Artificial Intelligence (AI) technology, its advantages, disadvantages and applications. From AI approaches, the computing world has gained many benefits. The ability to learn from AI is more flexible and powerful. It is mainly used in real time systems because of its fast response, low computational time and achieving parallelism. One of the greatest challenges of modern science is to make communication between human and computer. Mohammad Al Raba bah, Abdusamad Al Marghilani and M.A. Eyad<sup>7</sup> proposed an application to transform wavelet for reducing

the value of artificial neural network for speech recognition task. This speech recognition system describes informative signs and voice signals and uses Genetic algorithm to train neural network. Lei Yanmin, Wang Xiaoli, Ren Liye and Feng Zhibin proposed a kind of artificial landmark recognition system based on Omni vision sensor to know the location and navigation. This system works based on colour feature extraction, region segmentation and feature screening. This system is simple, fast and effective for real time applications. Nil Goksel-Canbek and Mehmet Emin Mutlu<sup>9</sup> reviewed the concept of Personal Digital Assistants (PDA) and Intelligent Personal Assistants (IPA). IPAs such as Google Now, Apple's Siri, etc., are implemented in mobile's Operating System to get useful and timely information. IPAs are also associated with Artificial Intelligence (AI) to provide interaction between human and computer. This system accepts only common link language. Hui Liu, Houshang Darabi, Pal Banerjee and Jing Liu<sup>10</sup> examined various wireless indoor positioning systems and its set of properties to evaluate location systems that is used in many popular applications. This paper revealed accuracy, precision, complexities, scalability, robustness and cost of many positioning algorithms. Prasanna G and Ramadass N proposed<sup>11</sup> a method for home automation using sound intelligence that is mainly useful for physically challenged people. Existing methods use wired networks and speech signal is transmitted through online. This method uses the concept of speech recognition using Hidden Markov Model Toolkit (HTK) which converts the speech to text and transmits offline. Xiaohua Zeng, Abraham O.Fapojuwu and Robert J.Davies<sup>12</sup> reviewed the performances of home appliances using Hidden Markov Model speech recognition system. The results showed that it is feasible to use voice as the control method. We get better recognition results when we maintain noise at the certain level, limited grammar with small vocabulary, clear and confirmative voice. Marcus E.Hennecke, K.Venaktesh Prasad and David G.Stork<sup>13</sup> proposed a method for speech recognition systems that uses both acoustic and visual signals. Automatic Speech Recognition accuracy improves by the algorithm that is based on deformable templates that infers lip dynamics and is analysed by visual signals. This system improves recognition accuracy even at low noise situations. Pallavi V.Hajari and Ashwini G.Andurkar<sup>14</sup> proposed a method for intelligent home security system which consists of facial recognition for finding the face of family member and voice recognition for finding the identity of words spoken by the persons. This method is implemented using Raspberry Pi because of its low cost, stable operating system in real time applications.



**Fig 1 Applications of Artificial Intelligence**

### III. TECHNOLOGY STACK

In this project, we have integrated many technical components and established a seamless functionality among them. Our technological stack is characterized as follows:

*A. Physical Layer:* This layer comprises of the devices with which the user interaction takes place.

- *Raspberry Pi Model B:* The Raspberry Pi 3 Model B is the third generation Raspberry Pi. The technical specifications of Raspberry Pi 3 include Broadcom BCM2387 chipset, 1.2GHz Quad-Core ARM Cortex-A53, 802.11 bgn Wireless LAN and Bluetooth 4.1 (Bluetooth Classic and LE), 1GB RAM, 64 Bit CPU, 4 x USB ports, 4 pole Stereo output and Composite video port, Full size HDMI, 10/100 BaseT Ethernet socket, CSI camera port for connecting the Raspberry Pi camera, DSI display port for connecting the Raspberry Pi touch screen display, Micro SD port for loading the operating system and storing data, Micro USB power source, fully HAT compatible, 40pin extended GPIO to enhance “real world” projects.
- *Raspberry Pi Sense Hat:* The sense HAT is an add on board for the Raspberry Pi including LEDs, a joystick and lot of sensors.
- *USB Speaker:* A USB Speaker is a speaker that relies on one connection (a USB connection from your PC) to provide both audio and power to the listener. Streaming audio is sent via the USB interface and power is provided through the USB connection.

- *USB Microphone:* The USB Microphone is a quality microphone with a “built in” interface so that it can be plugged directly into the USB port. A USB microphone contains all the elements of a traditional microphone: capsule, diaphragm, etc. Where it differs from other microphones is its inclusion of two additional circuits: an onboard pre amplifier and an analog-to-digital (A/D) converter.

*B. Application Layer:* This layer consists of the following components:

- *Alexa Skills Kit (ASK)* - The Alexa Skills Kit (ASK) is a collection of self-service APIs, tools, documentation, and code samples that makes it fast and easy for us to add skills to Alexa.
- *Amazon Web Services (AWS) Lambda* - AWS Lambda is a responsive cloud service that inspects actions within the application and responds by deploying the user-defined codes, known as functions.

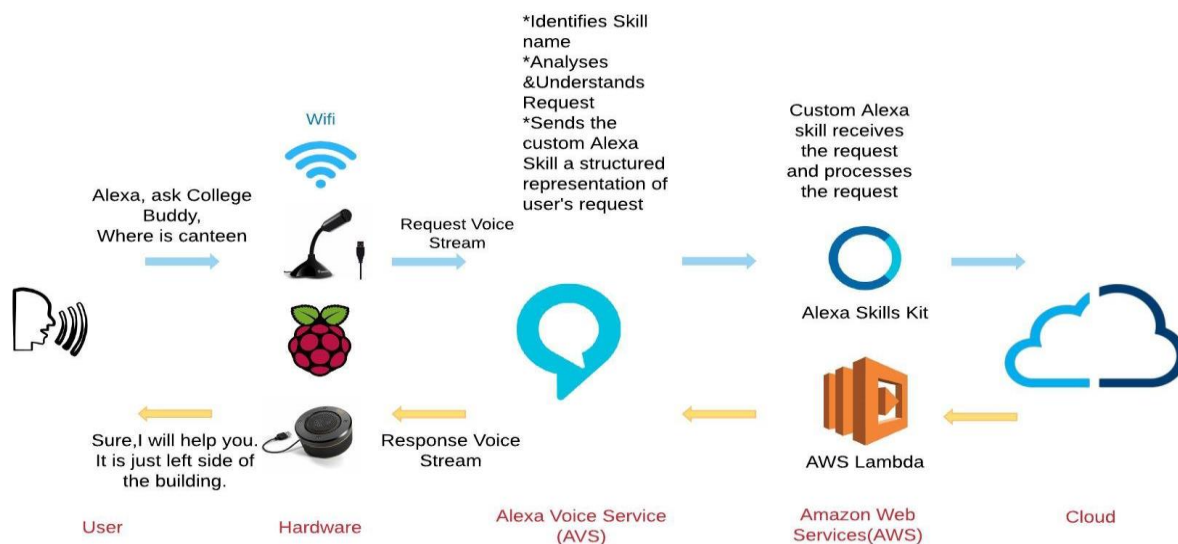
*C. Programming Layer:* The source code of all our programs are written in Node.js

- *Node js* - Node.js is used to seamlessly integrate AVS with Raspberry Pi. Node.js package system is called npm which comes with a lot of libraries making it a very efficient and flexible choice for programming. Node.js is a server-side platform built on Google Chrome’s JavaScript Engine (V8 Engine).

### IV. PROPOSED SYSTEM

A. *System overview*: The following diagram depicts our system overview. When a user speaks, the audio input is given to USB microphone and is processed by Amazon Alexa. Our System relies on Raspberry Pi 3 Model B as it satisfies the hardware requirements and also does all the computations. Raspberry Pi is a mini computer which uses ARM 7 Microcontroller. It has four USB Ports, a Ethernet Port, a HDMI Port, an inbuilt 802.11n Wi-Fi, Bluetooth 4.0(BLE), a Camera interface, VGA Audio Port, GPIO pins and a micro SD card port. Its inbuilt Wi-Fi is responsible for connecting it with the cloud service. Alexa is the cloud based service that handles all the speech recognition and machine learning. The collection of tools, APIs, reference solutions, and documentation available in Alexa make it easy for us to build with Alexa. Amazon has released Alexa Voice Service (AVS) API that allows the customized skills of Alexa to integrate with devices and applications. AVS is the intelligent voice control service. It provides cloud-based automatic speech recognition (ASR) and natural language understanding (NLU). The voice of Amazon Alexa is generated by a long short-term memory artificial neural network. Alexa is able to perceive what the users are saying using Natural Language Processing (NLP) algorithm. Alexa uses NLP techniques trained by the developers and the user community of Amazon to process user requests and cater to their individual needs. The AVS can be triggered using the keyword “Alexa”. The Alexa Skills Kit (ASK) is a collection of self-service APIs, tools, documentation, and

code samples that makes it fast and easy for us to add skills to Alexa. The skill/application that we have developed using ASK can be triggered using the voice command, “Alexa, ask my college buddy, where is canteen?” Here, Alexa is the default wake word. It wakes up the device and tells that the user wants to talk to Alexa. Ask is the starting phrase used to specify the type of request that users are using. My college buddy is the invocation name that user’s will say to launch the skill. “Where is canteen” is an utterance. When a user asks Alexa to open the customized skill, it is routed to AWS Lambda function. AWS Lambda is an event-driven, server less computing platform provided by Amazon. It is a compute service that runs code in response to events and automatically manages the computer resources required by that code. AWS Lambda supports the code written in Java, Python and Node.js, and the service can launch processes in languages supported by Amazon Linux (includes Bash, Go & Ruby). Once Alexa is triggered, it sends a request to lambda in the form of JSON object and runs a script on the cloud written in Node.js programming language. We have chosen Node.js programming language as it can seamlessly integrate AVS with Raspberry Pi. It is a web server that opens a file on the server and returns the content to the client. It eliminates waiting and continues with the next request. Node.js package system is called npm which comes with a lot of libraries making it a very efficient and flexible choice for programming. The lambda function received the request and



**Fig 2 System overview**

responds to Alexa with another JSON object, which includes output speech in the form of text. Alexa parses the JSON object and speaks the words in the Speech Synthesis Mark-up Language (SSML) value from the output text

object. SSML is a mark-up language that provides a standard way to mark-up text for the generation of synthetic speech. This output speech is given to the user through USB speaker.

System/ Solution	Accuracy	Precision	Complexity	Scalability	Robustness	Cost
Snap Track	5m-50m	50% within 25m	High	Good	Poor	Medium
Ubisense	15cm	99% within 0.3m	Real time response	2-4 sensors per cell	Poor	Medium to High
TIX	5.4m	50% within 2.7m	Low	Good	Good	Medium
EIRIS	<1m	50% within 1m	Medium to High	Good	Poor	Medium to High
Smart Focus	2-15cm	50% within 15cm	Medium	Good	Good	Medium to High
Spot On	Depends on cluster size	N/A	Medium	N/A	Good	Low
MPS	10m	50% within 10m	1s	Excellent	Good	High
College Buddy	Depends	N/A	Low	Excellent	Good	Low

**Table 1 Comparison of various Indoor positioning Systems**

#### V. ANALYSIS:

Table 1 compares the current system with the proposed system and different performance measurement criteria are observed.

#### A. EXPERIMENTAL SETUP:

To test our application, we deployed the Amazon Alexa Skill that we developed on Raspberry Pi 3 Model B kit. The Raspberry Pi which we used for development purpose requires a power source and is powered using 1.5A mobile charger. USB Speaker and USB microphone are connected to 2 USB ports in Raspberry pi 3. Raspberry pi is connected to a Wi-Fi which does not have any firewall setup on it.

#### B. RESULT

*User* : Alexa, open my college Buddy.

*Output*: Hello, I am College Buddy. Welcome to PSNA College Campus. I am here to help you to find your way.

*User* : Alexa, ask my college Buddy, available UG courses.

*Output*: The Seven under Graduate Courses available in PSNA are B.E Civil Engineering, B.E Mechanical Engineering, B.E Electronics and Communication Engineering, B.E electrical and Electronics engineering, B.E

computer Science Engineering, B.E Bio Medical Engineering and B.TECH information technology.

*User* : Alexa, ask my college Buddy, features of your college.

*Output*: PSNACET is a premier institution in Tamilnadu with International standards. It was established in 1984 at the outskirts of Dindigul Township as a response to the clarion call made by the public for a quality engineering institution in this part of South Tamilnadu. This prestigious institution, at present, offers 7 UG courses and 8 PG courses in Engineering and also MCA and MBA.

*User*: Alexa, ask my college buddy, guide me to principal room.

*Output*: From the gate go straight. You will find the Main Building, in ground floor. Turn right and reach HRDC hall. Principal Sir Mahendran's room is on the left side

*User*: Alexa, ask my college buddy, where is canteen.

*Output*: Sure, I'll help you. Go Straight .Take 4<sup>th</sup> left. Walk for 3 minutes. You will find canteen on the left side.

#### VI. CONCLUSION

As a conclusion, it is hoped that with this project, benefits could be reaped by users seeking for help on locating their whereabouts indoors. The computing world

has a lot to gain or benefits from various AI approaches. There is no need to devise an algorithm in order to perform a specific task. They are also very well suited for real time systems because of their fast response and computational times which are due to their parallel architecture. Out of all existing systems mentioned in Table 1, this proposed system serves its best by decreasing the power consumption and the complexity of design while maintaining accuracy and speed of the system.

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