

Voice Recognition by Google Home and Raspberry Pi for Smart Socket Control

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Abstract—In recent years, due to the progress of information technologies, the home-living pattern has been increasingly supplanted by smart home. Although smart home style can bring enormous benefits to people, the technology becomes ubiquitous in these years. Enterprises still cannot integrate the functional divisions of smart home mode. Consumers are hard to rummage the products they need. Therefore, in this paper, we build a tailor-made function for users without their attempt, we made use of Google Home's voice recognition with the conception of machine-learning to prove the feasibility analysis about fulfilling the users' needs by a smart home pattern with the design of machine learning. The experiment let users give comments to Google Home's voice recognition, then transfer the Bluetooth signal to Raspberry Pi to control devices.

Keywords—*smart home; IoT; machine; learning; raspberry pi; bluetooth 4.0*

I. INTRODUCTION

The development of IoT (Internet of Things) had been evolved in several study fields (like Semantic Web or Health Care). In these fields, numerous studies of smart home systems certificate that smart home becomes a crux role in IoT studies.

Smart home entails the buildings which furnish a reliable, expedience circumstance to suffice the needs of modern lifestyle. Therefore, among the applications of technology industry development technology, the construction of living needs in response to the smart home during the current stage become the inevitable trend of housing construction. Smart home is mainly in the construction of residential housing must provide convenient functions, such as security, disaster prevention, health care, convenient and comfortable, and energy savings which rely on sustainable development and carbon reduction function. To play a specific effect to enhance the quality of living space, the construction of these tasks need to use the technology of communication technology. Through the Netcom facilities platform, the integration to play a specific effect to enhance the quality of living space and to achieve the purpose of smart home.

Smart home is a variety of home automation equipment. It plays a holistic and efficient service functions to ensure the

safety of house living, health living environment, and to provide a comfortable quality of house living. To create Humanized living environment, smart home can also reduce the waste of electricity to bring great benefits.

The problem or consumer disputes may be quite tricky to install the extra system function or replace the responsible company. If you want to add system, you'll need to destroy the decoration which may be expensive. Therefore, this paper is committed to the way through the machine learning that users do not need to spend a lot of costs under the premise of the need to use the smart home system functions.

In addition to the convenience and scalability of the system of smart home, it needs to be improved control convenience. Lärka and Markus Schinle [2] proposed smart home with mobile devices to get the convenience of remote control. Not only can efficiently deal with home systems but also to further enhance the user's desire to use the home system. The system expands the wisdom of the family system to smart city system.

This paper focuses on researching the machine learning model to combine Google Home's with Google Assistant Personal Voice Assistant to customize a service to meet the new needs of users. The experiment goal is by learning the user's voice commands that Google Home can use Bluetooth to open the Smart Bluetooth Socket to control devices.

II. RELATED WORKS

A. Internet of Things

Internet of Things is to allow all the functions of independent objects to achieve interoperability on the Internet. Internet of things has wireless network technology as an infrastructure for things and objects connection. In the Internet of things, everyone can use electronic tags to connect real objects to the Internet. These tags can be found on their specific information.

In the era, the Internet of Things has involved rapidly. Everyone's life is getting more and more convenience. Therefore, in the era that network developed prevailing and high penetration of mobile devices and use Internet of Things to develop a conception of smart home. The system combine the mechanisms of the home with the network and performing remote operations through mobile devices and voice-activated technology.

The major companies have also launched such as Amazon-echo, Apple TV 4 Home-Kit and other intelligent home control center products. Google also had officially launched the Google Home as the products. Google Home is a smart home control center with remote control of home appliances and monitoring of home environmental data.

However, Google Home itself combines the home wireless play center and Google Smart Voice Assistant. Google Assistant voice assistance allows users to simple control instructions to achieve the needs of the functions by speaking commands.

Seyit Alperen Celtak [3] proposed smart home and the user's remote interaction mode, through voice controls the Smart Bluetooth Socket and to combine with the machine learning to achieve the new model which can satisfy the needs of smart home users

B. Machine Learning

Machine learning is a branch of "artificial intelligence". In the field, aiming to automatically analyzes the law from the data, and use the algorithm to predict the unknown information. Machine learning has developed into a multi-field interdisciplinary, involving the theory of probability, statistics, approximation, convex analysis, computational complexity theory and other disciplines in the past 30 years.

The pattern adopted by Zheng-Xian qi [4] who used Bluetooth to connect the coordinates and through three different machine learning methods (K-means analysis, support vector machine analysis, and linear discriminant analysis) to carry out Bluetooth indoor positioning. Machine learning mainly with the inferred statistics is more closely. So it is called Statistical Learning Theory. In this paper, the method of keyword analysis is primarily used to make the device understand and implement the user's commands. In this paper, we use LSA(Latent Semantic Analysis) and TF-IDF(term frequency-inverse document frequency) to analyze user's commands.

TF-IDF, is a numerical statistic that is intended to reflect how important a word is to a document from collection corpus. It is often used as a weighting factor for searches of information retrieval, text mining, and user modeling. The TD-IDF value increases proportionally to the number of times a word appears in the document but it is often offset by the frequency of the word in the corpus, which helps to adjust for the fact that some words appear more frequently. Nowadays, TF-IDF is one of the most popular term-weighting schemes. For instance, 83% of text-based recommender systems in the domain of digital libraries use TF-IDF. TF is the frequency of occurrence of a word, the formula is as formula (1).IDF is the

reciprocal of the word appears in the file, the smaller the data contains the word as formula (2).

$$tf_{i,j} = \frac{n_{i,j}}{\sum_k n_{k,j}} \tag{1}$$

$$idf_i = \log \frac{|D|}{|\{j : t_i \in d_j\}|} \tag{2}$$

Next, we classified the results of the words which have been analysis by TF-IDF into three sets, named as: ON, OFF, UNIDENTIFIED, and numbers as C1, C2, C3. The result showed as Table I.

TABLE I. WORDS AND CORRELATIONS MATRIX

Commands/Status	C1(ON)	C2(OFF)	C3(UNIDENTIFIED)
Turn on	4	1	1
Turn off	0	5	1
Turn the device on	3	0	3
Turn the device off	2	3	1
Hello	0	1	5
("Turn on the device" in Chinese)	0	0	6

C. Raspberry Pi

Raspberry Pi is a Linux single board computer. It was developed by the British Raspberry Foundation which aimed to promote basic computer science with low-cost hardware and free software. The 700-bit BCM2835 processor, 256MB of memory (B-type has been upgraded to 256 MB of memory). Raspberry Pi use the SD card as a storage medium and has an Ethernet, two USB interfaces, a USB interface, HDMI (support sound output) and RCA terminal output support. The operating system is open-source of Linux.

In the studies of the Internet of things, the raspberry faction has many applications. Its operating system can not only operate itself but also has access to wireless networks and Bluetooth chips. With the development of things networking conditions, raspberry itself has variety of hardware connections with USB interface.

You can connect the camera and keyboard or mouse to facilitate the development. Vladimir Vujovic[5] proposed the use of raspberry as a Web sensor application in the wisdom of residential. The raspberry faction as a small server which connected to the raspberry through the router and sensor is network node. Raspberry pi can tell the indoor temperature and humidity. The authors [5] suggest the benefits of using raspberry is that the use of Linux operating system has a rich open source can be used, with cheap and low power consumption.

Through the cloud service API.ai is to write the API.ai function. We linked the API.ai function with Google Home by Google account. Google Home received the commands which

will be written by the API.ai instructions' judgment and reply. If the API.ai judged to be "open the Smart Bluetooth Socket," it will inform the user through the voice assistant to open devices. Otherwise, it is closed. Google Home's Bluetooth function can't be modified their format through the back-end directly. Therefore, in this experiment, the controls Smart Bluetooth Socket must be completed by Raspberry.

BluePy is a suite that provides APIs to connect Bluetooth to low-power devices based on Python language. Currently, it runs on Linux, primarily using Raspberry Pi to develop it, but also run on x86 Debian-Linux operating systems. By writing a BluePy program. We turned the Raspberry Pi to connect to Google Home's Bluetooth pairing request. Then, Bluetooth open the smart Bluetooth socket.

If the release of Bluetooth closed, the smart Bluetooth socket is turned off. Google Home will receive the user instructions to upload to the API.ai database side to record the user behavior for further analysis. The raspberry faction will also be the wisdom of the outlet control records to upload to the cloud Database for statistical data to promote experimental research.

However, the reason for this study through Google Home for remote operation rather than raspberry is Google Home as a home appliance system in the center of the system. With Google Assistant personal assistant and Google home support a large number of services. .

However, the Raspberry Pie itself is not equipped with the understanding of the family system compatible with the package; it cannot be through the raspberry division experimental system to integrate other intelligent home systems. Zhe-Yi, You [6] and Yuan-Yu Ding [7] analyze the fuzzy logic by the tree plums, so that the raspberry can be judged and operated the foundation of the information which returned by the wisdom socket.

D. Bluetooth 4.0

Yuan-Yu Ding [7] proposed Smart Bluetooth Socket which uses Bluetooth 4.0 chip and control chip through the Raspberry Pi to control the Smart Bluetooth Socket. Smart Bluetooth Socket is a device of IoT; this device has RTC (Real Time Clock) device to record time. It can record the time at a certain point and in time switch or after a certain period to turn off the device or open the device. User can use the background control device program to control the function. Smart Bluetooth socket structure includes the Bluetooth module, RTC module, Bluetooth smart socket. In the original development, it hopes can find a technology which has not only low power consumption but also carry fast reaction time. Bluetooth technology is currently responsible for maintaining its technical standards by the Bluetooth

Technology Consortium (SIG), which has more than 20,000 corporate members whose territory is distributed in telecommunications, computers, networks and consumer electronics.

The RTC module used in this experiment refers to an electronic device that can output the actual time like a clock. It is usually used to integrate circuit and is also called a clock chip. This term often indicated devices that have capability on a personal computer, server, or embedded system. However,

many systems that require precision will have this capability. This article uses the RTC module to remember the time. The maximum value of the first year of up to 2099 years.

Google Home is a smart home centering product launched by Google Enterprise in 2016. Google Home has three main functions. The first one is Google Smart Voice Assistant. Google Assistant provides users with voice search and life reminders. The second one plays as Home Multimedia Center house wireless media player, built-in wireless speaker device.

The software design is based on the cast operation agreement, with the home chrome-cast collaboration, anytime, anywhere to play audio and video content. The third is to be a house controller which control the device in the smart home system. Among them, Google Assistant's voice assistance is the main function of this experiment. Through the user's behavior, Google Home can be issued to the device operating requirements.

III. SYSTEM ARCHITECTURE AND RESEARCH METHODS

The overall system architecture is shown in Figure 1. Users through the Google Home voice control instructions to understand the meaning of commands. Through the Raspberry Pi, it sent the signal to drive the Smart Bluetooth Socket or control the relevant electrical appliances. These manipulations will be recorded in the cloud's database for future analysis applications.

The functions of each part in Figure 1. (1)API.ai: compile the AI's code for Google Home, and analysis the records of commands which returned from Google Home for statistics. (2) Raspberry Pi's back end & Cloud Database: programming BluePy's code to operate the Bluetooth and Smart Bluetooth Sockets. (3) Google Home: When the AU receives an instruction about turning on the device, turn on Bluetooth and its pairing function, and return the situation to tell the user whether the device is turned on. (4) Raspberry Pi: Return the service records of Smart Bluetooth Socket to the Cloud Database. When Raspberry Pi receives a Bluetooth match request, turn the Smart Bluetooth Socket on or off through Bluetooth. (5) User: Give instructions to turn the device on. (6) Smart Bluetooth Sockets: By Raspberry Pi's attachment switch on its power.

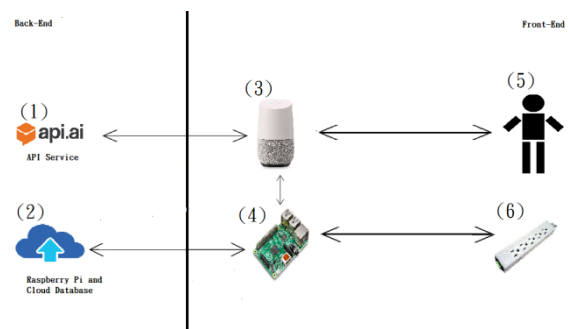


Fig. 1. The architecture diagram of experiment

Shi-Xin Chen [8] proposed the construction of three principles of smart home. The first term is the function of remote controlling. The second principle is the transmission of Bluetooth and information security-related system level, and the last principle is the system for disaster prevention and

defense of the judgement. To achieve the above three principles, the system can be classified as a sufficient security and confidentiality. However, the experimental content does not contain the third principle, so the previous two principles as a benchmark for the experiment.

This paper investigates the establishment of an open domain chatbot database through the services provided by API.ai and compiles an API.ai that can interact with the user on the basis of the specific keywords. Once the user issues the instruction, the API.ai will set the protocol according to the intent. In response to the user's instructions and in the intention, we established the thesaurus (as an entity). The pre-entred keywords are mainly stored in the thesaurus and by the intention to crawl and analysis.

In API.ai training model, the system will continue to receive the instructions and the glossary paired and make a default response. On the basis of the record after the analysis of the new keywords into the lexicon, the system followed by some training.

We can let the API.ai gradually grasp the correct keywords into the API.ai's thesaurus (entity). When the training is completed, it can achieve the real needs of users. API.ai can be released to many platforms. Google Home's default backend System Google Cast is one of them. On the other hand, Yu-Lin Wen [8] proposed four characteristics of the intelligent family system context model. First, if the knowledge is defined correctly, it can be understood and played in different entities. Second, if the knowledge can be reused, a substantial reduction needs to transfer and uses of information. Third, the modeling method has the ability to expand and to support the field of knowledge. Fourth, the models can provide formal logic inference and verification.

Through the API.ai's business services provided by the line of training and the training will be required by the experiment written in the instructions. When Google Home received the user's instructions, the comparison can be carried out and correct reply and operation. The API.ai training process is shown in Figure 2.

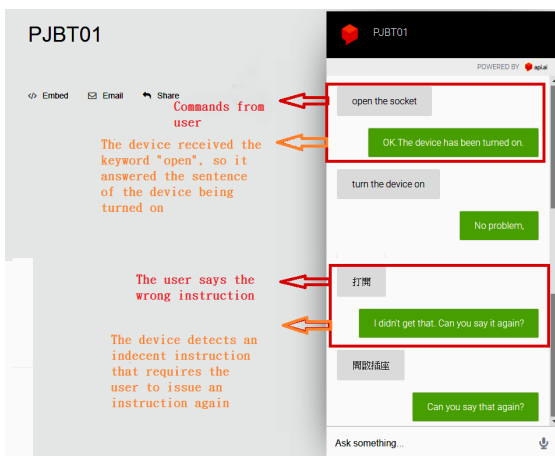


Fig. 2. The interface of AI training process

When Google Home can respond correctly to the user's instructions, you can use the instructions to turn on and off

Bluetooth on the back of the Google Cast settings. BluePy is a suite that provides APIs to connect Bluetooth to low-power devices in Python. When Google Home completes Bluetooth, it will be controlled by the BluePy API for Bluetooth smart sockets. Currently, it runs on Linux. It primarily uses Raspberry Pi to develop it, but it will also run on x86 Debian Linux operating systems.

Lärka[9], Ian-Harvey provided BluePy on Github. While the Raspberry Pi is written to receive the signal from Google Home, it will be able to use BluePy to control Smart Bluetooth socket's switch. The Bluetooth smart socket is a Bluetooth-based and intelligent mobile device to medium of communication. Using Bluetooth 4.0 low-power chip achieves power saving[10]. The transmission of information by the intelligent mobile device is to pass information and let the Bluetooth smart socket data format responding. Bluetooth smart socket can only give the bit format data. The Bluetooth smart socket using the hexadecimal information to illustrate data and commends. Bluetooth smart socket data format at the beginning of "AA", the end of "55". The check code is for the value of the front of the sum of the total. The data format also joined the check code to prevent data in the transmission format is not correct.

When Google Home can perform the API.ai, you can trigger Google Home's Bluetooth feature through voice-activated behavior. However, Google Home's Bluetooth signal cannot be modified by the back-end, only can be used by simple switched. So we use the Raspberry Pi to receive Bluetooth signals from Google Home and Smart Bluetooth Socket's function settings. The experiment uses low-power Bluetooth and traditional Bluetooth technical specifications shown in Table II.

TABLE II. Bluetooth technical specifications

Specification	Traditional Bluetooth	Bluetooth Low Energy
Frequency of radio	2.4 GHz	2.4 GHz
Distance	10 M/100 M	30 M
Speed of Data transmission	1-3 Mb/s	1 Mb/s
The amount of throughput	0.7-2.1 Mb/s	0.2 Mb/s
Time of Data transmission	100 ms	<6 ms
Network Topology	Distributed Network	Star-bus
Power Consumption	1	0.01 to 0.5
Maximum operating current	< 30 mA	< 15 mA

IV. EXPERIMENTAL RESULTS

The experiment started from August 15, 2017 with 58 times of dialogue training, and has captured the user's commands to turn on the Smart Bluetooth Socket. API.ai service provides a training model to determine whether to respond the command of the device by detecting the keywords.

When a sentence cannot be judged, it will further react to whether the user has opened the device or not. The training record is shown in Figure 3. API.ai will show the daily test

record of the training into a line chart which will show the number of tests in the next day in time. The second line chart shows the frequency of the commands whether activate the keywords in one day.

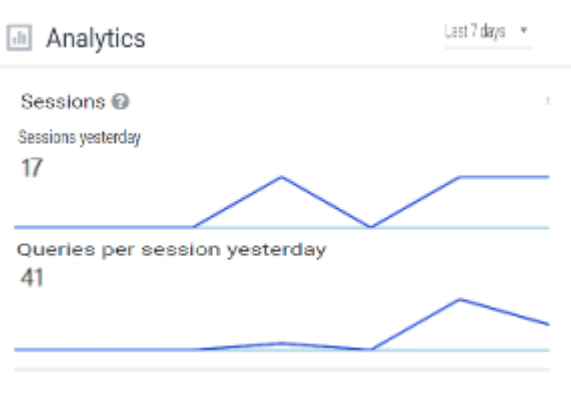


Fig. 3. Statistic records of AI training

After completed the training and the activation of Smart Bluetooth socket, we started experimenting with Google Home for Smart Bluetooth Socket through the trained API.ai. However, the results of the test that Google Home's operations were able to send back to the Google Account's database. In the API.ai internal database, the Bluetooth trigger mechanism belongs to Google Home, so the data of instructions were the success to activate the Smart Bluetooth Socket.

Google Home can read the contents of the instructions and issued from the user by the trained API.ai which connected with Google account. Therefore, we can compare the guidelines issued by the user, and the API.ai set the trigger keywords to complete the application of machine learning. There are statistics on the switch that operates the Bluetooth smart socket in the operations of users. Figure.4 shows the contents of the instructions that Google Home received from users.

When the user orders an instruction such as opening the device, the Smart Bluetooth Socket turned on and the data of this operation and the time of use are recorded. When the user speaking an instruction (such as Hey), the instruction is not related to the device's switch; it is not categorized to the statistics of the Smart Bluetooth Socket's operation. The system provides the developer new keywords to learning operations. The experimental results are shown in Figure 4.

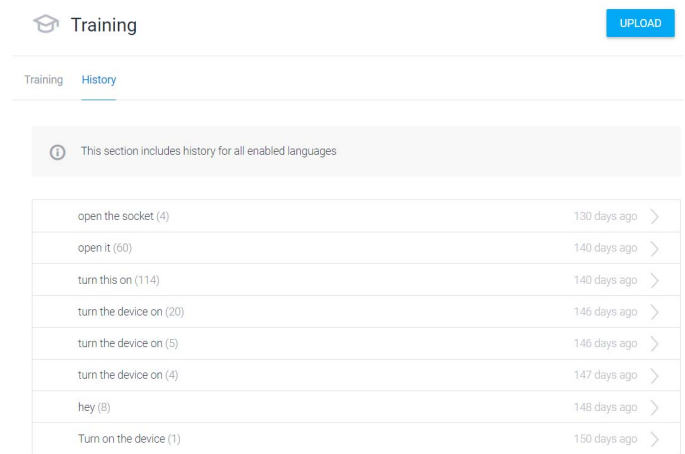


Fig. 4. Records of commands which Google Home returned to user and its frequency

When the above tests are completed, we can start the experiment of voice control with Raspberry Pi, Google Home and Smart Bluetooth Socket by Bluetooth. The difference between the first experiment of voice control with Raspberry Pi, Google Home and Smart Bluetooth Socket and the second experiment of voice control with Smart Bluetooth Socket and Raspberry Pi are Google Home control providing more flexible and more applications resources. In Table I, the trial of voice control with Raspberry Pi, Google Home, and Smart Bluetooth Socket was tried to figure out whether can a user command on Google Home to turn on the Bluetooth of Google Home. The Bluetooth signal of Google Home shall activate the Raspberry Pi, and the component of Raspberry Pi: BluePy can turn on or off the Smart Bluetooth Socket. So this experiment does not test the RTC module in the timing function, but the switch function of Smart Bluetooth Socket instead, the experimental results shown in Table III.

TABLE III. The linking test data of smart Bluetooth socket and google home

Commands of user	Orders	Time	Status of socket
turn the device on	on	2017/8/21 11:10	on
turn the device off	off	2017/8/21 11:11	off
wake the socket	on	2017/8/21 11:13	on
("Turn on the device" in Chinese)	invalid	2017/8/21 11:44	off
("Turn on the socket" in Chinese)	invalid	2017/8/21 11:46	off
open it	on	2017/8/22 14:02	on
Ready	on	2017/8/22 14:04	on
Play radio	invalid	2017/8/22 14:16	on
Turn on the device	on	2017/8/23 10:55	on
stop the working device	off	2017/8/23 11:57	off

V. CONCLUSIONS

In this paper, we proposed an architecture for a new intelligent family service for users through the machine learning applications. The system is highly feasible to complete the smart home control through machine learning using Google Home voice command, Raspberry Pi and Smart Bluetooth Socket. In the future, we will further improve the system structure and machine learning ability. We will try to figure out how to work with different users in the system to complete the machine learning training and to meet the needs of users. In addition, we hope to build a combining machine learn and remote operation of smart home to integrate the smart home model. We will try to manipulate more intelligent smart home devices with mobile devices.

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