

# IoT Smart Home Design for the Elderly Living Alone

Qizheng Yan

The Experimental School Affiliated to Nanjing Normal University, Nanjing210046, China

## Abstract

Elderly people living alone face problems such as memory loss and poor safety awareness. However, elderly people have less understanding of smart home and electronic equipment, and some smart devices are complicated to operate, which do not meet the needs of elderly people. Therefore, this paper designs an Internet of Things (IoT) smart home system with automatic prompt, automatic start, monitoring and alarm functions, and takes automatic air conditioning as an example. The realization process is discussed in detail. It aims to improve the convenience of living alone for elderly people.

## Keywords

Internet of Things; Smart Home.

## 1. Introduction

The latest data show that by the end of 2022, the elderly population over 60 in China has exceeded 280 million, accounting for 19.8% of the total population, an increase of 0.9 percentage points compared with 2021 [1]. It can be seen that China's aging society is becoming more and more serious. At the same time, fewer children in the family have become a trend of development, which means that elderly people living alone have become a common state in the life of the elderly. Due to the absence of children, memory loss, low education level and physical health, the elderly often face a variety of safety problems in their daily lives. For example, the inability to help with sudden illness, unable to contact relatives after going out and getting lost, accidental falls, stumbles, and accidents in cooking, electricity, and bathing may bring life risks to the elderly. At the same time, some elderly people living alone are easy to become the targets of criminals because of their age, low vigilance, and mobility difficulties. In addition, how to let the elderly living alone enjoy their old age has become the focus of social attention.

Taking elderly people living alone as the research object, this paper has an in-depth understanding of the psychology and survival of elderly people living alone in China. Based on the living needs and behavioral habits of elderly people, the IOT smart home is designed to solve the problems of home environment monitoring and home safety for elderly people living alone. First of all, through reading literature, this paper learns that under the influence of traditional Chinese culture, elderly people living alone in China are generally reluctant to cause trouble to others and become a burden to their children. Therefore, some elderly people are unwilling to live with their children or seek care and help from their children [2], making daily care of elderly people living alone a difficult problem. In addition, elderly people living alone in China rely on pensions. In 2022, the average pension of Chinese retirees is 3,230 yuan, while the retirement of elderly people in rural areas is only 100 yuan due to problems such as social security payments [3]. Therefore, it can be seen that the income of elderly people living alone is less. In addition, old age is a stage of decline in intellectual level, physiological function degradation and memory loss, so the elderly have poor cognition, acceptance and use of new things and high-tech products. Based on the above discussion, this paper believes that the design of an IOT smart home for elderly people should meet the following characteristics: 1. It has rich and powerful functions. For example, the regular voice prompt function reminds the

elderly to take medicine regularly. Environmental monitoring function, monitoring home temperature, humidity, etc. Alarm function, alarm for some dangerous situations. The function of external contact: Once the elderly are in danger, It can contact the community and the children of the elderly in time. 2, the operation is simple and convenient, in line with the use of the elderly habits, after the completion of the basic settings, the elderly can use a key to start the function, and you can make the smart home to complete the above functions. 3. Low cost. According to the consumption habits and income level of the elderly, the design and the required hardware should be economical, applicable, durable, and cost-effective. This design has the characteristics of timeliness, convenience and durability, which can meet the needs of the elderly and their children. The technology that can meet the above needs is the IoT technology. Based on IoT technology, this paper designs a smart home system that meets the needs and behaviors of the elderly.

## 2. Research the Status of Internet of Things Technology and Application

Smart home is a variety of communication technology development, the application of modular structure, combined with user needs to establish a family-integrated service and management integrated system. And one of the key technologies is the Internet of Things(IOT), The first concept of the Internet of Things (IoT) was expressed in 1999 at the Massachusetts Institute of Technology's Auto-ID Experimental Center in the study of Internet-based Radio Frequency identification(RFID)system is proposed to associate the Internet with RFID and other real object information perception technologies, to realize intelligent identification and management [4]. The IOT is a great extension of the existing Internet, making intelligence integrated into daily life, so as to realize the free communication between users and arbitrary objects, but also make communication between objects possible. The architecture of the Internet of Things generally includes three layers, and the first layer is a perception layer composed of sensors and short-range communication devices, which is used for the perception of the surrounding environment and the data acquisition of the corresponding devices. The second layer is the network layer, which is an Internet environment that can provide public services and communication and is used to transmit the collected data information. The network structure formed by the network layer can accurately and privately transmit information, and it is a transmission channel with fast data transmission speed, compatible and stable performance established by using a variety of transmission technologies [5]. The third layer is the application layer. This level has a variety of mobile or fixed rich user terminal devices. The IoT is to seamlessly integrate these three parts, connecting the real physical world with the virtual electronic information world, to realize the concept of the IoT.

IoT technology is widely used in smart city, smart agriculture, smart power grid, smart home and other aspects. Zhang Xiaoguang not only uses S5PV210 to control the internal electrical equipment in the family, but also uses ZigBee to complete the interconnection of the network and information among the devices, and collects the internal household appliances and real-time environmental information through the PC to ensure the accuracy of the system [6]. In the smart home system, Du Lei adopts data fusion algorithm to realize the design of home security, and also sets linkage control in case of abnormal security. In addition, it can provide users with real-time remote viewing of abnormal home equipment through the PC [7]. Wang Qimin used Eclipse and Android SDK development tools, combined with ZigBee, gateway and control terminal, to design an APP that can be controlled in real-time, and the switch control of lamps can be achieved through the voice discrimination function [8]. However, the design of the Internet of Things smart home focuses on the algorithm direction, and few studies are based on the needs of a certain group, making the design of the Internet of Things smart home unable to land in real life. Even if the relevant product technology is developed, because it does not take

the actual needs of users as the starting point, the IoT smart home design lacks practicality and convenience.

### 3. The Needs and Functions of the IoT Smart Home System for Elderly People Living Alone

This paper takes the elderly living alone as the design object, considering that the elderly face problems such as memory loss and poor safety awareness. The elderly stay at home for a long time and frequently use a variety of furniture, the elderly have less understanding of smart homes and electronic equipment, and when designing the functions of the IoT smart home, the principles of security, convenience and simplicity are followed. IoT smart home systems meet automatic prompt, automatic start, monitoring and alarm functions. Automatic prompt refers to reminding the elderly to take medicine, take a bath, sleep and so on at a given time. Automatic start function refers to the automatic start of TV, air conditioning and other equipment at a specified time. In addition, it can monitor carbon dioxide and smoke concentration in the environment, and once the smoke concentration is too high, it can automatically report to the community and family members to reduce the safety hazards of the elderly living environment. As shown in Figure 1.

**Table 1.** The functional requirements of the IoT home system

Function	content	Operation	Hardware and software
Automatic prompt function	set medicine, bath, sleep time, automatic voice to remind the elderly to take medicine, bath		voice prompt system
Automatic start function	After setting the turn on time of the TV, air conditioner and water heater, the equipment will turn on automatically.	Automatically turn on the water heater, automatically turn on the bathroom lights, Automatic TV, air conditioning	Water heater, bathroom light, TV, air conditioning
Environmental monitoring function	Monitor smoke concentration Monitor room temperature Once the room temperature falls below a certain value, it automatically turns on the air conditioning or heating equipment, and once the room temperature rises above a certain value, it automatically turns on the air conditioning to cool down.	Air conditioning or other thermal equipment is programmed to turn on or off	Temperature and humidity sensors, air conditioners, other thermal equipment, smoke sensors
Alarm function	Once the smoke concentration is high, it will trigger the smoke alarm device and alert the family and the community.		Smoke sensor

### 4. The Overall Design Scheme of the IoT Smart Home System for Elderly People Living Alone

Based on the requirements and functions of the system, and considering the factors of ease of operation and price, this paper chooses Raspberry Pi 4 Model B, Xiaomi Bluetooth hygrometer, Xiaomi fire smoke alarm and Xiaomi gateway as the hardware facilities, and realizes the unified control of smart home on the home assistant.

The Raspberry Pi is a small computer based on the Linux operating system. It contains a processor, SoM, memory, and eMMC flash memory (shown in Figure 1). It has the advantages of small size and low price, with independent input and output interfaces, which can be used to connect various devices, such as sensors, actuators, motors, etc. Raspberry Pi has strong

communication capabilities and scalability and can upload sensor data to the cloud through Wi-Fi, Bluetooth, wired or wireless networks and other ways to achieve real-time data collection and transmission. At the same time, different protocols can be used for data exchange, such as http, mqtt, CoAP, etc. Although the Raspberry Pi has limited memory and storage space, it supports the expansion of external storage devices (such as USB hard drives and SD cards). At the same time, Raspberry Pi programs and various open-source software, such as Apache, MySQL, Python, etc., can be used to process, analyze and store the collected data. In addition, the controller or actuator is connected to the Raspberry Pi and connected to the cloud through the IoT technology, remote control and monitoring can be achieved, for example, the switch, temperature, humidity, etc. of smart home devices can be controlled through mobile phone apps or web pages to achieve intelligent management and control. It can be seen that the Raspberry Pi data storage, processing, remote control and monitoring functions meet the needs of this system.



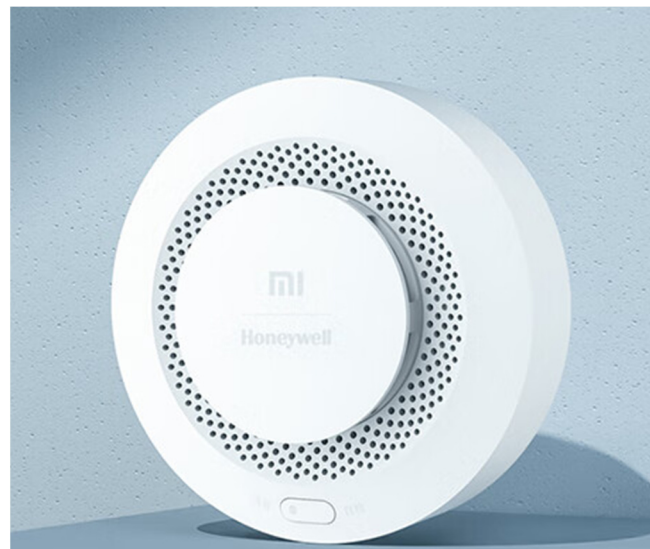
**Figure 1.** Raspberry Pi

This system uses Xiaomi Bluetooth hygrogaph, as shown in Figure 2. The hygrogaph can be linked to other smart devices and automatically turn on air conditioning and thermal equipment by setting the temperature. And its energy consumption is low, power saving and compact design.

This system uses Xiaomi fire smoke alarm (as shown in Figure 3). The device is used with devices that support Bluetooth Mesh gateway function, such as Xiaomi intelligent multi-mode gateway, and can be linked with other smart devices to achieve remote alarm. The device detects an alarm sound exceeding 80dB(A)\* within 3 meters when a fire breaks out.



**Figure 2.** Xiaomi Bluetooth hygrometer



**Figure 3.** Xiaomi fire smoke alarm

Xiaomi intelligent multi-mode gateway, can make Bluetooth Mesh, Zigbee and other mainstream communication protocol smart devices closely connected, accept its instructions and scheduling, execution of intelligent scenes in daily life, support 2.4GHz and 5GHz dual-frequency Wi-Fi, with strong wall penetration and anti-interference ability. It supports RJ45 cable network port direct connection, so that remote control, and device linkage data transmission is more stable and efficient. As shown in Figure 4.

This system is developed and applied based on the Home Assistant platform. Home Assistant is a Python-based home intelligence platform that can track and control all devices in the home and provide an automated control platform. Home Assistant integrates the communication protocols of Xiaomi, broadlink and other companies, and can directly discover and control the smart devices of these companies, and can also connect other devices through the mqtt protocol. Therefore, the Home Assistant is open source and free, can access more devices, the system is stable, and the power consumption is low.

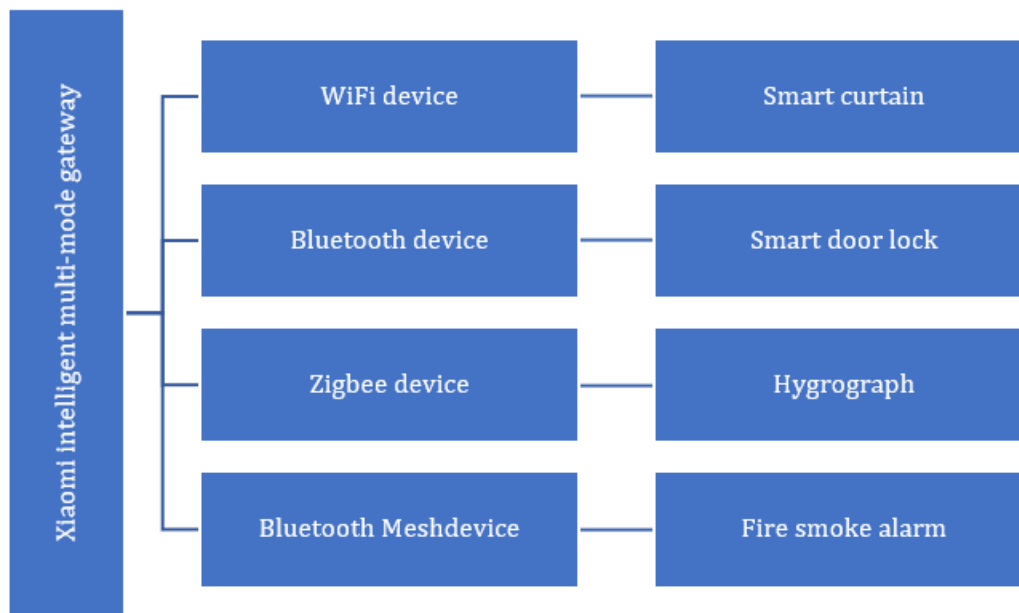


Figure 4. Xiaomi intelligent multi-mode gateway

## 5. The Realization of IoT Smart Home System for Elderly Living Alone

### 5.1. Device Startup and Installation

First, download the Raspberry Pi system image and use the balenaEtcher burning tool to burn the Raspberry Pi memory card.

Second, insert the memory card into the Raspberry Pi, plug in the network cable, and power up the Raspberry Pi.

Again, download and install the Home Assistants operating system

Then, connect the Xiaomi device to the Home Assistants. Configure the Bluetooth hygrograph and gateway using the Xiaomi APP. Click HACS in Home assistants, select Integrate (as shown in Figure 5), click Browse in the bottom right corner, search for add repository gateway3, and download.

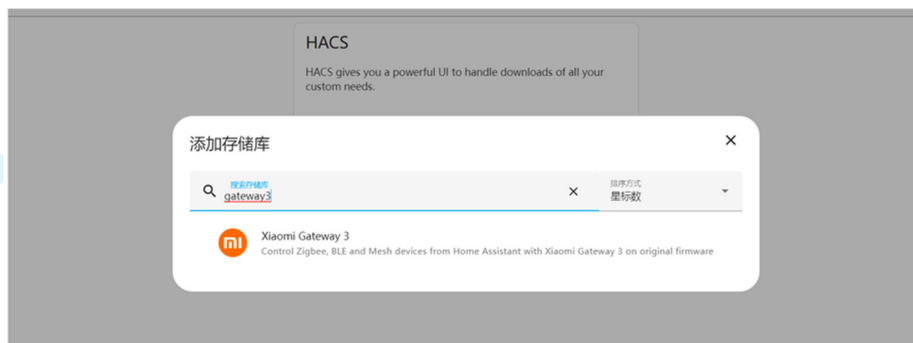


Figure 5. search for add repository gateway3 in Home Assistants

Next, configure the Xiaomi Gateway in the Home Assistant. Once the download is complete, restart the Home Assistant as shown in Figure 6. After restarting, add a new integration and add a Xiaomi account. Add the gateway3 integration again and Xiaomi Gateway will appear in the selection list. As shown in Figure 7. Enter the following command in the open telnet command:

```
{"method": "set_ip_info", "params": {"ssid": "\\", "pswd": "123123 ; passwd -d admin ; echo enable > /sys/class/tty/tty/enable; telnetd"}}
```

The sub-devices in the Xiaomi gateway, such as the Xiaomi fire smoke alarm and the Xiaomi hygroph device are connected to the Home Assistant.

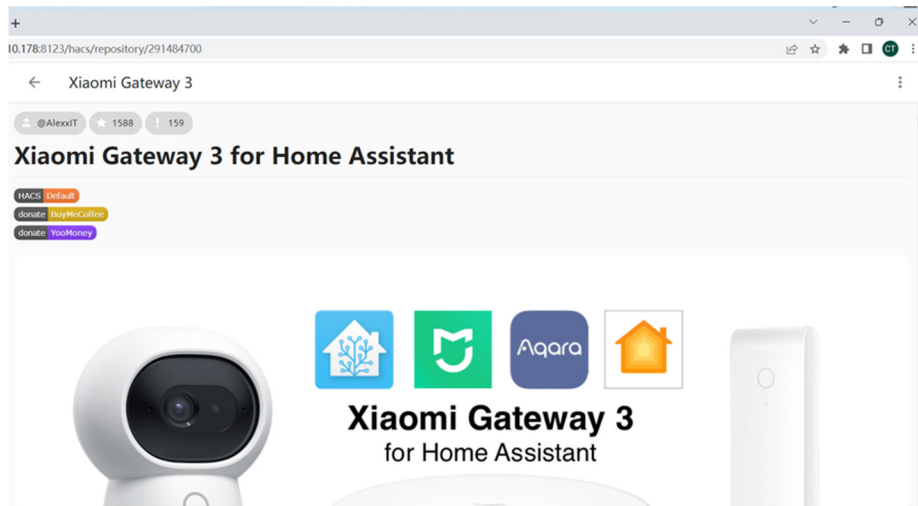


Figure 6. The page after downloading the repository

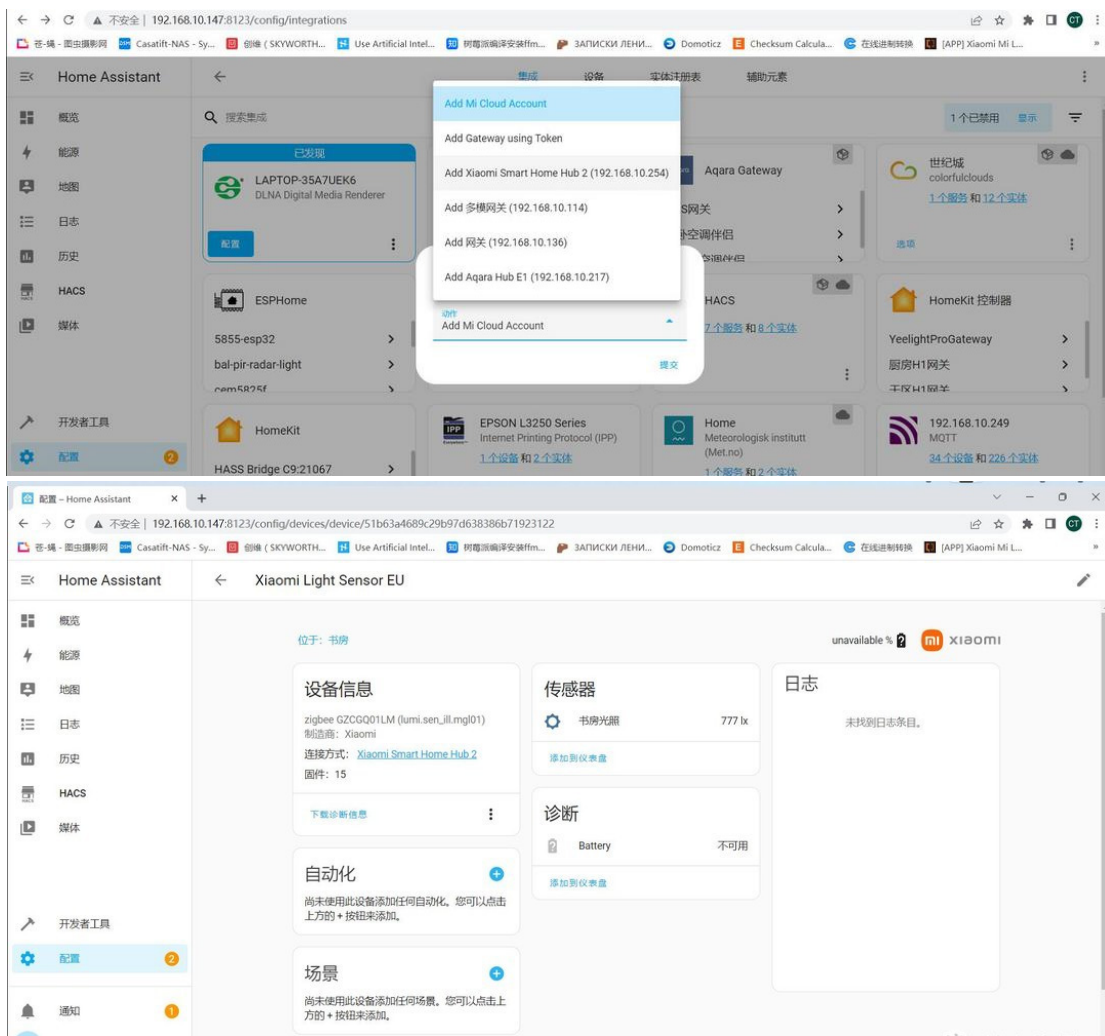


Figure 7. Adding the Xiaomi gateway and sub-devices

## 5.2. Intelligent Infrared Remote Control Device Access

Connect the intelligent infrared remote control to the router. In the Home Assistant platform, click the following path: Configuration - Devices and Services - Add New Integration. In the search box, enter: Broadlink, and add a Broadlink device.

Obtain the IP address of the intelligent remote control from the router, Enter it in the Host of the Connect to the device. The Home Assistant has completed the connection of the smart remote control of Broadlink WiFi.

## 5.3. Device Control

Broadlink WiFi intelligent remote control is an infrared transmitter, However, since the Home Assistant does not initially integrate such infrared command code data, it is also necessary to obtain the corresponding IrCode infrared command code through the manufacturer's App cloud service, so that the intelligent remote control can send infrared signals to the air conditioner. To realize Home Assistant to control the air conditioner by sending infrared signals through intelligent remote control, Home Assistant needs to know the infrared code of each button and store the information in Home Assistant.

### 5.3.1. Learning Infrared Commands

After Broadlink is integrated into Home Assistant, we can learn infrared button commands on the Home Assistant WebUI. On the Home Assistant Web page, go to the Developer Tools page and enter the Services Tab. On this interface, we can configure related commands through the UI. In the service drop-down box, select or enter: Remote control: Learn Command. At this time, what needs to be done is to learn the remote control infrared button command, and enter the following YAML format information in the text box;

```
service: remote.learn_command
```

```
data:
```

```
  entity_id: remote.zhi_neng_yao_kong_remote
```

```
  device: yaokong
```

```
  command: power
```

```
  command_type: ir
```

```
  alternative: true
```

```
/config/.storage # cat broadlink_remote_3
{
  "version": 1,
  "minor_version": 1,
  "key": "broadlink_remote_34ea34408627_c
  "data": {
    "yaokong": {
      "power": [
        "JgDoAGRlZZITNhMTEjcTEhMSEjcUNhIT
SFBEUERQSFBEUEhMSExMTEhMRFRMSERQSFBEUEhMS
1EzcTEhIADQU=",
        "JgDoAGRlZZITNxiTFDUSExITEjcTNhMT
SExMSEhMSFBEUEhQRFBQSExISExMSEhMUEhMTERQR
3FBESExIADQU="
      ]
    }
  }
}
```

Figure 8. Learning infrared commands

After the writing is completed, click the Call Service button. We press the switch button against the intelligent remote control with the air conditioner remote control, and then Home Assistant completes the infrared code learning of the switch button of the remote control of the air conditioner; In the /config/.storage directory of Home Assistant, we will also see the files created after learning. As is shown in Figure 8.

### 5.3.2. Sending Infrared Commands

Infrared instructions are sent using the developer page service call. Enter the following code:

service: remote.send\_command

data:

entity\_id: remote.zhi\_neng\_yao\_kong\_remote

device: yaokong

command: power

After clicking call service. Send the power-on infrared command, click the service call, send the off infrared command, test the response of the air conditioner. We write the code to configuration.yaml file and restart HA. The configured switch is displayed on the Home Assistant's home page. We can use this switch to control the air conditioner.

### 5.4. Configuration Automation

Open HomeAssistant and go to Configuration-Automation and Scene- Create Automation to create a new automation. From the interface, we can find that automation is composed of three parts: trigger conditions, environmental conditions and actions. Click the Add trigger button to see that Home Assistant provides a large number of trigger conditions, including device, location, time, calendar, status, and so on. Select state means that it is triggered when the state of the entity changes, and triggered when the temperature sensor detects that the temperature exceeds the set value. The selected time means that when the set time is reached, the air conditioner will be automatically turned on.

Take status triggering as an example. When the temperature sensor detects that the temperature exceeds 30 ° C, the air conditioner automatically starts. Go to Configuration - Equipment and Service, find the integration of entity access, click the device under integration, click the Xiaomi Bluetooth hygrometer, click the gear in the upper right corner of Xiaomi Bluetooth hygrometer detail card, we can see the ID of the Xiaomi Bluetooth hygrometer, and copy the ID to the entity input box of the trigger condition. It is also said that the system selects the status change of the Xiaomi Bluetooth hygrometer as the trigger condition.

Model	miaomiaoce.sensor_ht.t2
Lan IP	
MAC address	A4:C1:38:3B:A3:DF
Entity class	MiotSensorEntity
Home room	home 客厅
Miot type	urn:miot-spec-v2:device:temperature-humidity-sensor:0000A00A:miaomiaoce-t2:1
State property	temperature-2-1
Temperature-2-1	15.5
Relative humidity-2-2	61.5
Battery level	100%
State updater	cloud

Figure 9. Attribute selection of Xiaomi Bluetooth hygrometer in trigger condition

After selecting the thermometer, select the trigger attribute under the entity. As there are many attributes, we can open the thermometer details and select Temperature2-1, that is,

temperature as the attribute (Figure 9). Enter 30 in the Change Option of the trigger condition page. Finally, in the action column, set the first action to call the service, and enter the following code:

```
service: remote.send_command
```

```
data:
```

```
  entity_id: remote.zhi_neng_yao_kong_remote
```

```
  device: yaokong
```

```
  command: power
```

After the above steps, when the Xiaomi Bluetooth hygrogaph monitors the indoor temperature of 30 degrees, the air conditioning is automatically turned on.

## 6. Summary

Based on the observation of the living characteristics of the elderly living alone. First, this paper puts forward the design principles of the IoT smart home system for the elderly living alone. Secondly, Raspberry Pi and Home Assistant are used to complete the setting of automatically turning on the air conditioning, reducing the operational complexity of existing electronic products and providing convenience for elderly people living alone.

## References

- [1] <https://baijiahao.baidu.com/s?id=1779904193707071609&wfr=spider&for=pc>.
- [2] Meng Fang, Huang Jiahao. The living situation of the elderly living alone in rural areas needs urgent attention, Journal of the Party School of the CPC Nanning Municipal Committee.
- [3] <https://baijiahao.baidu.com/s?id=1779970438821389713&wfr=spider&for=pc>.
- [4] Zheng Jiye, Ruan Huaijun, Feng Wenjie, et al. Research progress in the architecture and application of agricultural iot. Chinese Journal of Agricultural Sciences,2017,50(04):657-668.
- [5] Teslyuk Vasyl, Kazarian Artem, Kryvinska Natalia,Tsmots Ivan. Optimal Artificial Neural Network Type Selection Method for Usage in Smart House Systems.Sensors (Basel, Switzerland),2020, 21.
- [6] Zhang Xiao-guang. Design and implementation of ZigBee-based smart home wireless network. Shijiazhuang (in Hebei Province).
- [7] Du Lei. Research and design of smart home security based on multi-sensor data fusion. University of Electronic Science and Technology of China, 2018.
- [8] Wang Qimin. Design and implementation of smart home system based on ZigBee wireless sensor network. Anhui University of Science and Technology, 2018.