

Design of IoT Home System for the Elderly based on Different Scenarios

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Abstract. China has entered an aging society. Based on investigating the living status of the elderly and smart home products at home and abroad, this paper puts forward a smart home system design based on Internet of Things according to the life needs of the elderly. The system has the functions of daily data collection, data transmission and prompt alarm in real time, which can meet the needs of remote real-time monitoring. It can transmit the processed information to users in time and receive indoor temperature, smoke concentration and other home environment information at any time. Once a dangerous situation occurs, the smart home system will alert the user so that the user can take measures in time.

Keywords: Internet of Things; Home System; Smart Home.

1. Introduction

With the development and popularization of Internet of Things technology, smart home systems have become a reality, bringing convenience and comfort to people's lives. The IoT creates a network where smart devices can combine data to infer, participate in decision-making and guide action. The Internet of Things (IoT) helps in maintaining homes, enforcing safety protocols, reducing household chores, and helping the disabled and elderly. People's homes, workplaces and communities are all permeated by a small but powerful equipment network. Through various information sensing devices and communication means at the same time, functions such as remote monitoring, automatic prompting, regulation, judgment, and maintenance are formed, thus building a systematic network with highly centralized control, operation, and maintenance [1]. It includes a local network composed of sensors and short-distance communication equipment, an existing Internet environment that can provide public services and communications, and various mobile or fixed rich user terminal devices [2]. The implementation structure of the IoT includes three layers: perception layer, network layer and application layer. The sensing layer collects information and operates the equipment. At this layer, chips, sensor modules and a sensor network constructed by the module are configured. The task of the network layer is to use networks or information technologies such as 5G network, Bluetooth communication and various network protocols to transmit data between independent networks and store and analyze data. The application layer is used to monitor and analyze the data of each project (as shown in Table 1) [3].

Table 1. Basic Architecture of IoT

Layer Name	Layer Content
The third layer: The application layer	Smart city, smart agriculture, industrial monitoring, smart home, telemedicine, etc
The second layer: The network layer	5G , Bluetooth, network protocol
The first layer: The perception layer	Chip, Sensor, Vehicle equipment, Camera, Infrared detection equipment, Infrared remote-control equipment

Based on the Internet of Things technology, this paper builds an Internet of Things system to serve the elderly and supervise their daily life in real time all day. The system has the characteristics of simple operation and comprehensive monitoring, such as supervising the daily behaviors and health status of the elderly. It is also connected with external personnel, such as communities or children of the elderly. Once an emergency occurs to the elderly, external service agencies and children of the elderly can receive relevant information and take rescue actions as soon as possible. Assist the elderly to live a more convenient life.

2. System Demand Analysis and Data Processing Flow

The functions of the system include automatic prompt, automatic startup, monitoring and alarm. Automatic prompt refers to reminding the elderly to take medicine, bathe, and sleep at a set time. The automatic start function refers to the ability to automatically start electrical appliances such as water heaters at a given time. Monitoring functions include environmental monitoring, physical health monitoring and daily behavior monitoring. As shown in Table 2.

Table 2. Functional Requirements of IoT Home System

Functions	Contents	Status change of required appliances	Required hardware and software
Reminder	Time reminder for taking medicine, bathing, and sleeping	Voice prompt	
Activation	Bath mode activated at 8:00 pm	Automatically start the water heater and automatically turn on the bathroom light	Water heater, bathroom light
Monitoring	Safety monitoring: whether the door lock is closed, and smoke concentration is monitored	Voice prompt	Smart door lock, smoke sensor
	Temperature monitoring: Indoor temperature: Once the indoor temperature is lower than a certain value, the air conditioner or heating equipment will be automatically turned on; once the indoor temperature is higher than a certain value, the air conditioner will be automatically turned on to cool down.		Air conditioning, heat preservation equipment and temperature sensor
Alarm	Once the smoke concentration is high, it will trigger the smoke alarm device	Smoke alarm device	

In the automatic prompt function, the system initializes first. During initialization, the system sets the initial value of the timer for subsequent use. Next, the system starts a timer and waits for triggering of a timer interrupt. The timer will run at preset intervals. When a timer interrupt is triggered, the system will determine whether the predetermined reminder time has been reached. If yes, the system will automatically send a voice prompt to remind the elderly to take corresponding activities, such as taking medicine, bathing, or sleeping (as shown in Figure 1). When an elderly person wishes to turn on the bathing mode, the system is initialized and then ready to execute the bathing mode. The system sets an initial value for the timer to control the duration of the bathing mode. Next, the system enters a timer interrupt state and periodically checks whether the timing time has expired. If the timing time has expired, the system will turn on the bathing mode according to the set process. The system will send instructions to turn on the bathroom lights and provide enough light for the elderly. After the bathing mode is executed, the process ends. In the bathing mode, the system will automatically perform operations such as initialization, timer setting, timing check and turning on the bathroom lights. The elderly can enjoy the bathing process more easily and conveniently (as shown in Figure

2). If the reminder time has not been reached, the system will return to the initialization state again and continue to cyclically wait for the triggering of a timer interrupt. Through this process, the system can periodically remind seniors to carry out various activities on time. The elderly can rely on voice prompts from the system to manage important activities of daily life.

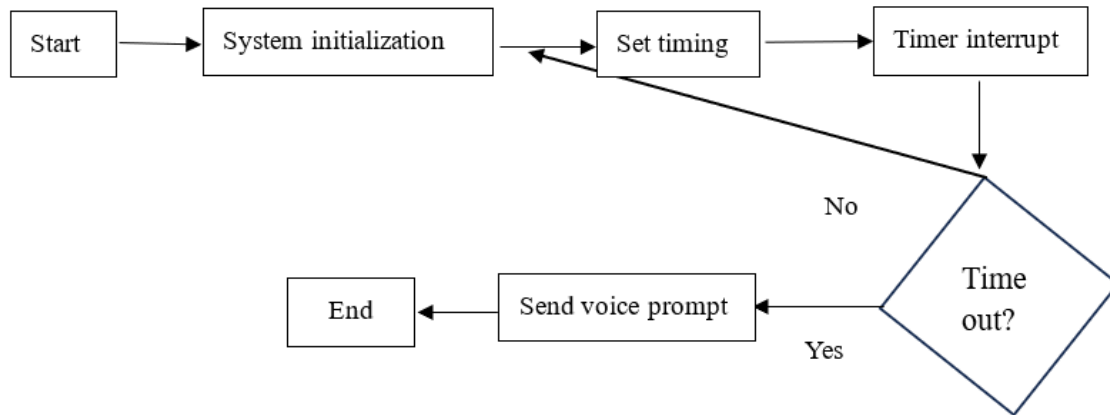


Figure 1. Workflow of Automatic Prompt Function

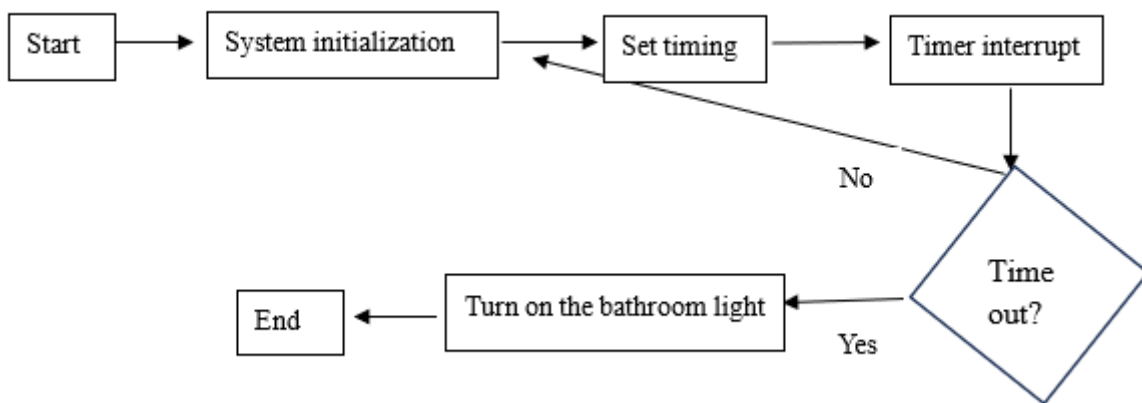


Figure 2. Workflow of Turning on Bath Mode

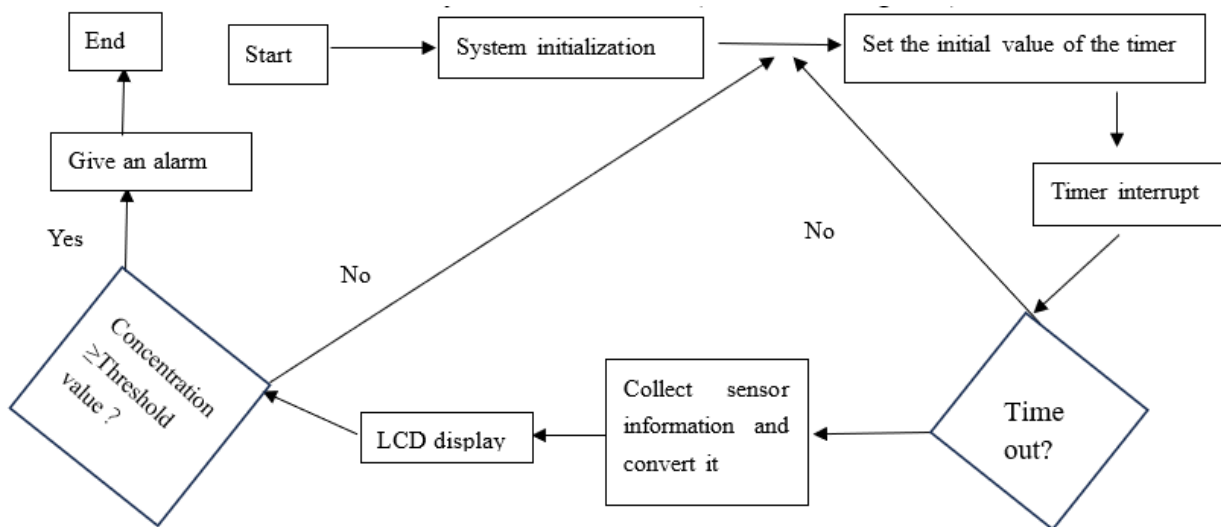


Figure 3. Workflow of Smoke Alarm

For the detection function of the system, environmental safety monitoring is the first step. The system can judge whether the smart door lock is closed. If not, it will give a voice prompt. In addition, the system can detect the indoor temperature through a temperature sensor. Once the indoor temperature

is lower than a certain value, the air conditioner or heating equipment will be automatically turned on, and once the indoor temperature is higher than a certain value, the air conditioner will be automatically turned on to cool down. The system detects whether there are fire hazards indoors through smoke alarms. Once the system finds a potential safety hazard, it will give an alarm in time and send reminder messages to relevant personnel to ensure that the living environment of the elderly is safe and reliable. (As shown in Figure 3)

3. System Hardware and Software Design

Based on the above system requirements design, the whole system is composed of four parts: indoor core server end, various sensing devices, user operation end and management platform. This section describes the hardware equipment and software systems required for this system.

3.1. Introduction to Raspberry Pi

This project is to design the IoT home system for the elderly based on Raspberry Pi server. It can centrally control various devices through various sensors and actuators, and access various Web applications [4]. The Raspberry Pi 4B uses the Broadcom BCM2711 processor, which is based on the ARM Cortex-A72 architecture. The processor adopts 64-bit execution mode and supports ARMv8-A instruction set. The ARM Cortex-A72 architecture has high single-thread performance, lower power consumption and strong multi-core processing capability. The ARMv8-A instruction set introduces a 64-bit execution mode, allowing the processor to handle larger memory space and more complex calculations [5]. The ARMv8-A instruction set also provides enhanced security features, virtualization extensions, and SIMD (Single Instruction Multiple Data) instruction set NEON support. Raspberry Pi 4B has relatively fast memory access and low cost [6]. However, since Raspberry Pi's operating system and software often provide support for specific architectures and instruction sets, it is important to ensure that the tools and libraries selected are compatible with the CPU architecture and instruction set of Raspberry Pi 4B when developing software (As shown in Figure 4) .

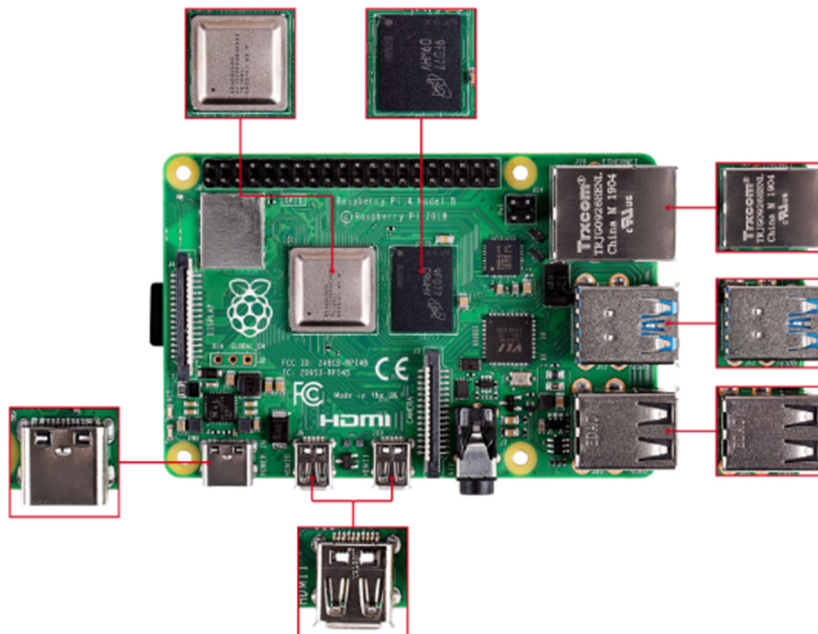


Figure 4. Raspberry Pi 4B

3.2. Sensor Introduction

The Xiaomi Mijia Bluetooth Hygrothermograph is an electronic device that measures its ambient temperature and converts input data into electronic data to record, monitor or signal changes in temperature. It is mainly used to measure the temperature and humidity of the environment. This

hygrothermograph has the advantages of long standby time, high measurement accuracy, convenient use, and smart interconnection with other smart products.

In this study, the fire smoke alarm of Xiaomi Smoke Guard is used. The smoke alarm adopts an optical maze design, which can sensitively capture smoke particles and give audible and visual alarms with high sensitivity and short response time. Powered by batteries, it is compact in design, lightweight and low in power consumption. It has a battery life of 5 years and is equipped with Bluetooth module, which can be smartly interconnected with other smart products.

In addition, Xiaomi Gateway is required for this article. In this paper, Xiaomi Smart Multimode Gateway is selected. It has dual-frequency Wi-Fi, supports Bluetooth and Bluetooth MESH Zigbee protocols, and supports direct wired network port connection, which can be linked with smart homes. In addition, Xiaomi infrared remote control is also required. This article uses BroadLink Smart Infrared Remote Control, which can also be connected to other smart devices.

3.3. Development Platform

This project is developed and applied based on the home assistant platform. The home assistant is a python-based home intelligence platform, which is usually installed on Raspberry Pi. With this platform, all smart devices in the family can be controlled uniformly. The home assistant integrates the communication protocols of Xiaomi, BroadLink and other companies to directly discover and control their smart devices. It can also connect with other devices through MQTT protocol. At the same time, it can interact with Apple's Apple HomeKit through plug-in extension and use Siri voice to control other smart devices [7]. Therefore, Home Assistant is open-source and free of charge. It can access many devices, with stable system and extremely low power consumption. The point is that Home Assistant is fully localized, does not need to be linked to the vendor's server and is out of vendor control. For example, after Xiaomi's gateway is connected to the HA, it does not matter even if the network is disconnected. It is still controlled by the HA and has strong autonomy. In addition, self-developed components can be used to realize linkage and automation between smart products [8].

4. Implementation Steps

To achieve the above functions, we first need to connect all sensors through a network and access the home assistant. The home assistant is used as the core to read sensor information, judge status and issue corresponding instructions to realize prompt, monitoring, alarm, and other functions.

4.1. Equipment Access

The devices used in this system involve different connection modes from multiple manufacturers. For example, Xiaomi Gateway is directly connected to the network through Wi-Fi, and sensors such as smoke alarms are connected to the gateway through Bluetooth. First, they need to be initialized and connected to the network separately according to the requirements of different devices. They are then connected to the home assistant system. The Xiaomi device is connected through the home appliance assistant plug-in Xiaomi gateway 3. First, click HACS in the left sidebar and select Integration. Next, click on the bottom right corner to browse and download repository search gateway 3. Click "Download" in the lower right corner and restart HA, then add new integration, Xiaomi Mijia account, and gateway 3 integration again. The gateway will appear in the selection list.

Enter the following commands in the open telnet command:

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

Gateway sub-devices are connected to the home assistant (as shown Figure 5).



Figure 5. Sub-device Access to HA of Gateway

In addition to Xiaomi devices, you need to add BroadLink Infrared Remote-Control Device in Home Assistant. Enter "Broadlink" in the search box of Configuration-Devices and Services-Add New Integration to add Broadlink devices. Obtain the IP address of smart remote control from the router and enter it into the Connect to the device window Host.

Through the above steps, the Home Assistant has completed the access of BroadLink Wi-Fi Smart Remote Control; Next, you need to configure the device control in Home Assistant. Configuring scenario linkage or writing scripts through the Web interface can also be realized by directly modifying the HA configuration file; Due to the different infrared command protocols of air conditioners from various manufacturers, Home Assistant does not initially integrate such infrared command code data. Wi-Fi smart remote control is only an infrared transmitter. It is also necessary to obtain the corresponding IrCode infrared command code through the manufacturer's App cloud service so that the smart remote control can send infrared signals to the air conditioner; Therefore, to control the air conditioner by sending infrared signals through smart remote control, Home Assistant needs to know the infrared code of each button and store this information in Home Assistant;

On the Web page of Home Assistant, go to the developer tool page and enter the Service Tab. In this interface, you can configure relevant commands through UI or YAML writing; select or input: Remote Control: Learn Command in the service drop-down box, and input information in YAML format 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
```

After the coding is completed, click the service button at this time, and the smart remote-control indicator will light up. Press the power on/off key in front of the smart remote control with the A/C remote controller. Because alternative parameters are configured, you need to press it twice to start up and shut down; At this time, HA completes the infrared code learning of the A/C remote control

power on/off button; The files generated after learning can also be seen in the /config/.storage directory of HA:

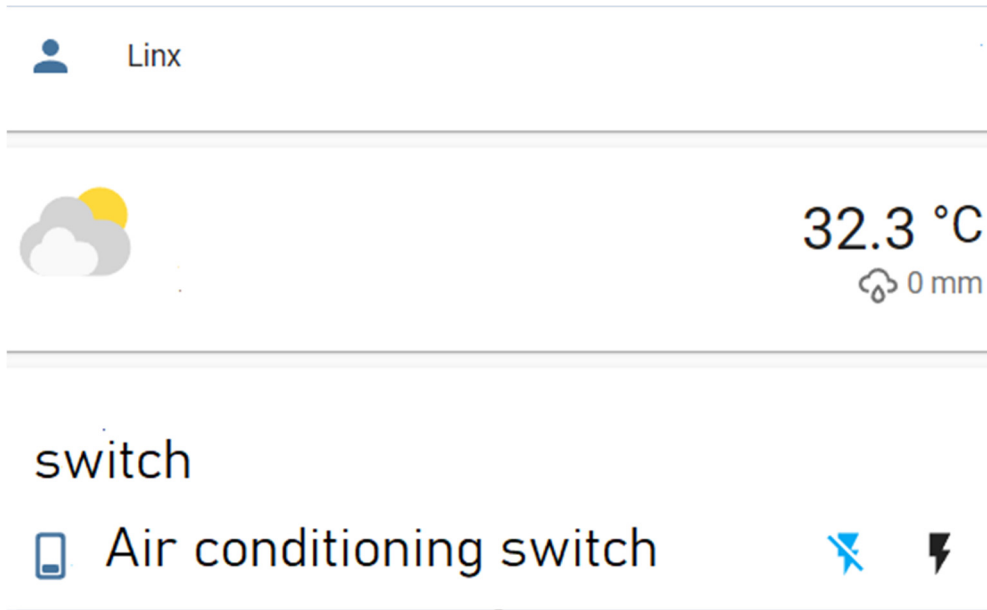


Figure 6. Page Display of A/C Control

Write the compiled code into the configuration. yaml file and restart HA. At this time, you will see the configured switch on the homepage of HA, so use this switch to control the air conditioner accordingly (as shown in Figure 6).

4.2. Configuration Automation Rules

Configuring scheduled tasks in the Home Assistant typically involves using Automation. You can use the YAML profile or Home Assistant's automated editor to set up timed tasks.

The specific steps are as follows:

- Open the user interface of Home Assistant.
- Go to the Configuration option.
- Select "Automation" in the left navigation bar.
- Click the "+" button in the lower right corner to create a new automation.
- Configure the Trigger part in the automation editor. Select "Time" as the trigger type and set the time condition you want. That is to say, the trigger condition type is time.
- Configure the Action part. Select the services and entities to perform, as well as the actions to take when triggered. The first action is set in the action bar as a service call, and the above infrared remote control sending command can be filled (Figure 7).
- In the automation editor, you can also configure other options, such as Conditions and restrictions on triggers.
- Click "Save" to save the automation configuration.

In addition to the above operations of sending A/C remote control instructions at regular intervals, more functions can also be realized by adjusting automation: the action bar is set as a voice reminder, which can realize regular broadcast of voice reminders for taking medicine, bathing, and sleeping. Modify the trigger to Xiaomi Smoke Alarm, which can automatically alarm in case of fire.

```
remote.send_command
1 service: remote.send_command
2 data:
3     entity_id: remote.zhi_neng_yao_kong_remote
4     device: yaokong
5     command: power
```

Figure 7. Configuration Actions

5. Conclusion

This paper understands the life needs of the elderly by reading literature and designs a smart home system based on the Internet of Things according to their needs. Emphasis is laid on the composition, functions, and related technologies of smart home system. Through the analysis of software requirements and key design, this paper analyzes the software design process of smart home system in detail, realizes the real-time monitoring, alarm, and feedback functions of the system, and achieves the function of smart elderly care. However, it is found that the compatibility of hardware equipment and development platform will affect the design of this system. Therefore, the IoT smart home for the elderly in the future needs to be able to integrate wired and wireless regulation functions reasonably and scientifically, and at the same time can also build a corresponding regulation system for any functional sector. And it is necessary to continuously improve the intelligence level and realize humanization and comfort.

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