Real-Time Smart Home Surveillance System of Based on Raspberry Pi

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Abstract

This research combines Raspberry Pi with the Internet of Things and the foundations of artificial intelligence to develop a real-time smart home surveillance system to improve safety at home. With a remote control method, people may check the safety of their own home in real-time. The realized smart system is based on Raspberry Pi 4B that adopts the Internet of Things architecture and combines several sensors and devices for home security to set up a safer home environment. The main method is to connect the Raspberry Pi to a network sharer or computer with a fixed IP and then input it into a computer or mobile phone to achieve remote control. To provide home safety for the elderly or the challenged people, the proposed system combines a voice control module to improve the user convenience.

Keywords: Raspberry Pi, Internet of Things, remote control, voice control

Introduction

Internet of Things (IoT) remotely connects, accesses, monitors, and controls the existing world entities through the Internet [1]. The rapid development and implementation of smart and IoT based technologies have allowed various possibilities in technological advancements for different aspects of life [2,3]. The main goal of IoT technologies is to simplify processes in different fields, to ensure better efficiency of systems, and finally to improve life quality. When the IoT is conceptualized towards home, it converts the common home to a smart one that is safer and automated. Recently, topics and issues of the smart home are attracting much attention [4-8]. In most home control systems, PC is used for remote controlling and monitoring, which needs space and has limited monitoring range with inconvenience to carry, higher setting, and maintaining cost, and so on.

In this paper, a real-time home surveillance system is designed and realized by using Raspberry Pi. The cheap price, low power consumption, and the availability of open-source software are major merits of using Raspberry Pi is in developing applications. Thus, it has been widely implemented in the development of IoT technology, as its reliability and available information on the Internet [9,10]. The purpose of designing and implementing the smart system is to provide the system at an affordable price at homes where people enjoy safety and comfort. For the safety of the elderly or the challenged people at home, the proposed system combines a voice control module to improve the operating convenience.

Methods and Procedure

Figure 1 is the architecture of the proposed system including four parts: the functions of remote control, voice control, home safety (related to IoT), and Raspberry Pi board. Using Raspberry Pi integrates the functions of other three parts successfully.

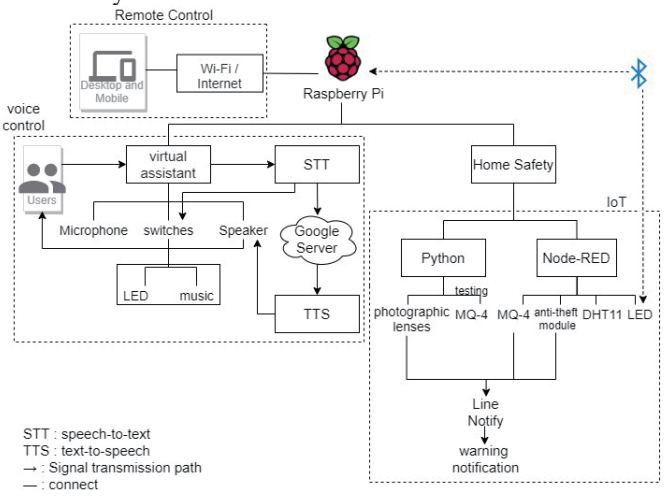

Fig. 1 System architecture

A. Remote Control

With the Raspberry Pi board, a computer (PC, Tablet) or mobile phone could remote-control devices at home via Wi-Fi or the Internet. To do this, the computer or mobile phone needs to remotely connect to the Raspberry Pi board with the VNC (virtual network computing) server and viewer [11,12]. Figure 2 shows how to remotely connect (computer/mobile phone and Raspberry Pi).

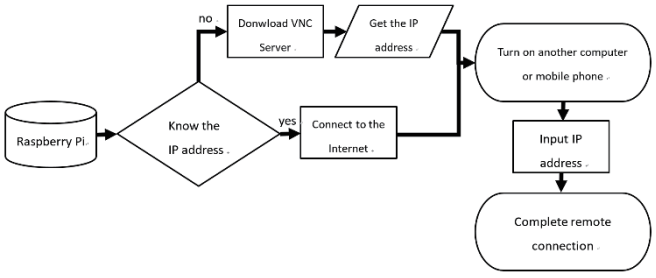

Fig. 2 Flowchart of a remote connection.

B. IoT and Home Safety

The proposed real-time home surveillance system consists of two principal monitoring functions: anti-theft and gas alarms and environmental sensors including temperature and humidity. Node-RED is a programming tool and provides a browser-based editor for wiring hardware devices such as APIs and online services together. The Node-RED enables designers to simply integrate all devices or modules to realize the IoT [13]. Figure 3 shows the programming using the Node-RED for a temperature and humidity sensor (DHT11 sensor). In this study, programming using the Node-RED for other objects such as

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LED, gas sensors (MQ-4 sensor), Micro Bits magnetic sensor, and photographic lenses, is similar to the one for DHT11 sensor.

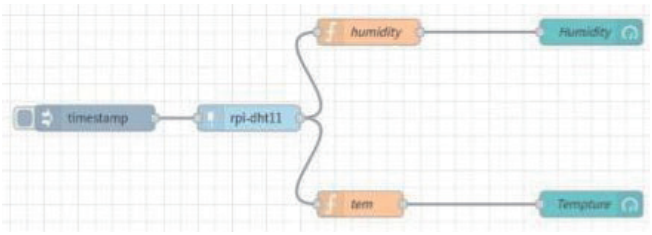

Fig. 3 Node-RED programming for DHT11 sensor (temperature and humidity sensor).

For home safety, video monitoring is considered for gas monitoring and anti-theft mechanism. After connecting to the Raspberry Pi board, the MQ-4 gas sensor is capable of normal operation by programming in Python for detecting harmful gas. Figure 4 shows a part of the coding for the MQ-4 sensor. If the density of harmful gas larger than a threshold, alarms notifies people through LINE.

```
import RPi.GPIO as GPIO
import time
CHANNEL=7
GPIO.setmode(GPIO.BCM)
GPIO.setup(16,GPIO.IN)
def action(pin):
    print ("Sensor detected action!")
GPIO.add_event_detect(16, GPIO.RISING)
GPIO.add_event_callback(16, action)
try:
    while True:
        print ("No abnormality")
        time.sleep(5)
except KeyboardInterrupt:
    GPIO.cleanup()
```

Fig. 4 the codes for the MQ-4 sensor.

Anti-theft function is construed for detecting the opening of a door/window, which is realized by a Micro Bit magnetic sensor that communicates to the Raspberry Pi with Bluetooth and a camera. When the detecting magnetic strength is smaller than the threshold, the system determines if the door/window is open and sounds alarmed as well as square LED array lights up. At the same time, the system alerts users with LINE to see screens.

C. Voice Control

The proposed system brings into voice control by using speech library and Google cloud service for speech-to-text (STT) and text-to-speech (TTS). Figure 5 is a flow chart of the conversion between STT and TTS.

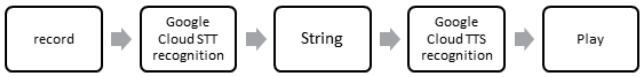

Fig. 5 Flow chart of the conversion between STT and TTS.

The virtual assistant, as shown in Fig.1, receives natural language instead of instructional sentences. For the user speaking in Chinese, a natural language processing (NLP) analyzer with Jieba which is a Python Chinese word segmentation module is applied to the system.

Validation

A. Remote Control

Figure 6 is a result of the remote connection in the proposed system. The screen of the computer and the mobile phone is the same, which can be verified that the mobile phone successfully connects to the Raspberry Pi. A successful remote connection also represents the successful remote control for devices connected to the Raspberry Pi by using a mobile phone.

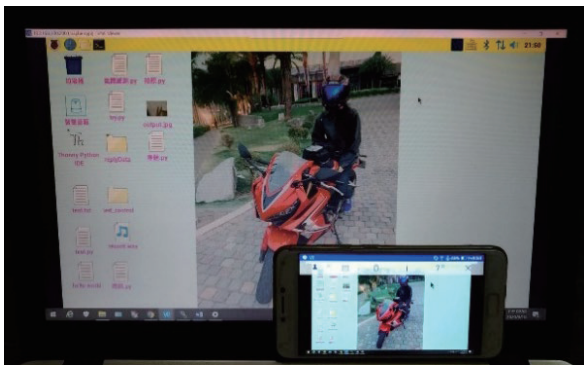

Fig. 6 Remote connection is successful.

B. IoT and Home Safety

A DHT11 sensor module connected to the Raspberry Pi measures temperature and humidity. Figure 7 shows an interface designed via Node-RED for sensing temperature and humidity.

Fig. 7 an interface designed via Node-RED for detecting temperature and humidity.

For home safety, gas monitoring and anti-theft mechanism with video monitoring are considered. For gas monitoring, the MQ-4 sensor detects a variety of harmful gases. Once the harmful gas appears, the proposed system sends an alarming message. Figure 8 shows a warning for harmful gas.

Fig. 8 a warning for harmful gas appearing.

For anti-theft functions, figures 9 and 10 show the different status of the door and corresponding alarm messages. When the door is closed, the square LED array does not light up and no alarm sounds as shown in Fig.9. Once the door is open, the square LED array lights up as shown in Fig.10 and the speaker connected to the Raspberry Pi sounds an alarm. At the same time, a LINE warning message is sent to the user and reminds them to see video screen as shown in Fig.11. Figure 12 is a corresponding video screen reviewed via mobile phone.

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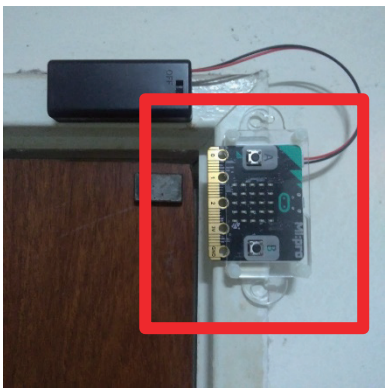

Fig. 9 When the door is close, the LED array does not light up and has no sound alarm.

Fig. 10 When the door is opened, a square LED array lights up, and the speaker connected to the Raspberry Pi sounds an alarm.

Fig. 11 a LINE warning that door is opened.

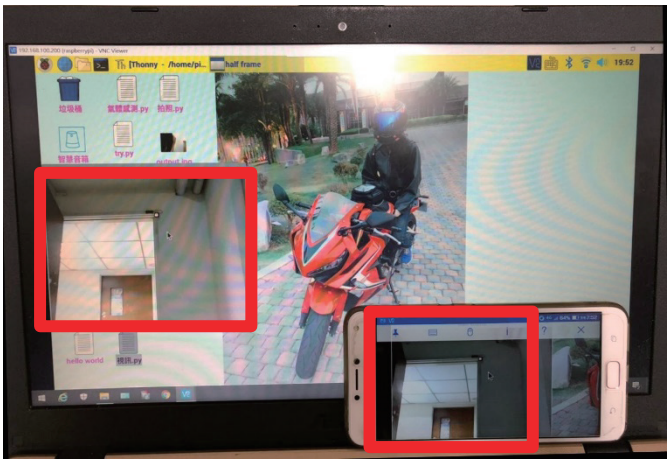

Fig. 12 a reviewed video screen (sent to mobile phone and computer) when the door is opened.

C. Voice Control

A demonstration of an LED via the voice control function of the proposed system is presented in the following website. The delayed phenomenon for the LED is because the cloud services STT and TTS are applied to the system. (https://youtu.be/s17IFjNTuPk)

Conclusion

This project proposes a home surveillance system, using Raspberry Pi, various sensing modules, and small devices to achieve essential home safety and smart home requirements. Remote control and foundational voice control functions are considered in the proposed system. Not only a computer (PC or Tablet) but also a mobile phone can be the control terminal to remote control the proposed system. People with limited mobility or the elderly also can easily control the system by using voice control functions. Advanced functions still are needed to develop. For example, operations to send warnings, the policy for the camera (photographic lenses), and the voice-control response delay are further developed to use cloud services.

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