Intelligent Umbrella Stand
Final Report

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Abstract

With the continuous development of science and technology, people's pace of life has become faster and faster, but there are many problems. For example, in daily life, many people often encounter the experience of rushing out in a rainy day and forgetting to bring an umbrella, which has brought great inconvenience to their life. Based on this problem, we use technologies such as Raspberry Pi, web crawler and Android development and design an intelligent umbrella stand according to the design concept of the Internet of things. By embedding the Raspberry Pi program into the common umbrella stand, the product can remind people to take an umbrella when going out on rainy days. At the same time, through the test and analysis of relevant data and comparison with the existing market solutions, we find that this intelligent umbrella stand project has a good market prospect. In addition, further development and improvement will be made in the future according to the existing limitations.

1. Introduction

1.1. Background Research

With the continuous development of science and technology, people's pace of life has become more and more compact, but there are a series of problems behind that. For example, starting from our own experience, all of our group members have encountered the problem that we get up too late in the morning and rush out to catch early classes, but we find it raining outside when we go downstairs and we have to run back to our dormitory to get an umbrella. Such a similar experience more than once not only wastes time, but also brings great inconvenience to our life. In view of this frequent and very troublesome problem, we came up with the idea of designing an intelligent umbrella stand that can remind people to take an umbrella when going out on rainy days.

However, these are only based on our subjective ideas. Whether there is a certain practical value still needs a certain background research. Therefore, we first studied the climate of Hangzhou. Figure 1 shows the average monthly rainfall in Hangzhou. According to the concept of meteorology, rainy month refers to the precipitation of more than 4 inches (about 100 mm) in a month. From the figure, we can see that Hangzhou has nearly seven rainy months (March to September) every year, which fully illustrates the rainy climate characteristics in Hangzhou. The greater possibility of rainfall makes it necessary for people in Hangzhou to take an umbrella when they go out.

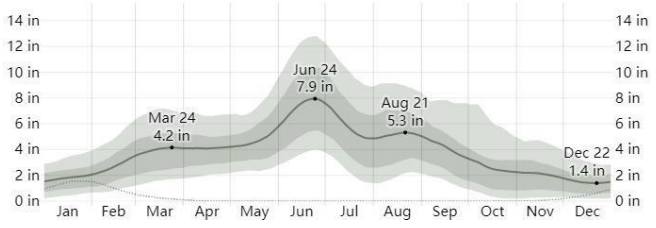


Figure 1: Average Monthly Rainfall in Hangzhou Source: Weather Spark

We also noticed the phenomenon of short-term heavy rainfall in Hangzhou. Through literature reading, we have found that short-term heavy precipitation is very common in Hangzhou. As shown in Figure 2, especially in summer, the monthly

short-term heavy rainfall in Hangzhou exceeds 30 times, which is very frequent.

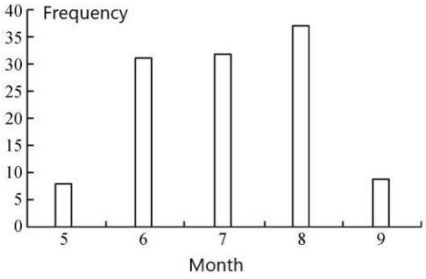
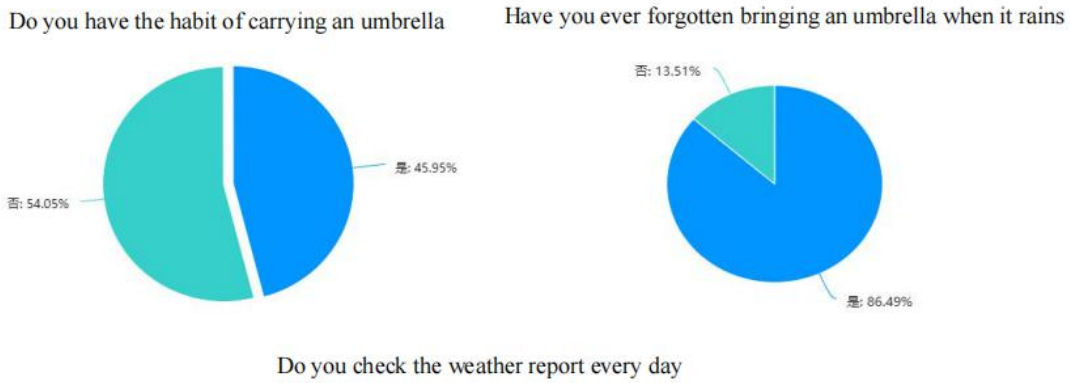


Figure 2: Monthly occurrence times of short-term heavy precipitation in Hangzhou Source: Zhejiang meteorological

Considering the rainy climate characteristics and frequent short-term heavy precipitation in Hangzhou, we think our idea and product planned to be developed are suitable for those rainy cities like Hangzhou, but we still need to know whether some people, like us, are very confused about the experience when going out in a hurry and forgetting to bring an umbrella on rainy days. Therefore, we did the corresponding questionnaire survey. Figure 3 shows our questionnaire results. The total number of respondents was 137. As shown in the figure, We have selected some representative questions in the questionnaire. According to the results of the questionnaire, we found that many people have the habit of going out without taking an umbrella. Among them, 86.49% of the respondents had the experience of forgetting to bring an umbrella when it was raining, and 62.16% did not bring an umbrella from home when it was raining (37.84% of the respondents directly chose to buy it outdoors). At the same time, 78.38% of the respondents, like us, hope to have a product at home to remind them to bring umbrellas on rainy days, so as to solve their confusion of going out in a hurry and forgetting to bring umbrellas on rainy days.



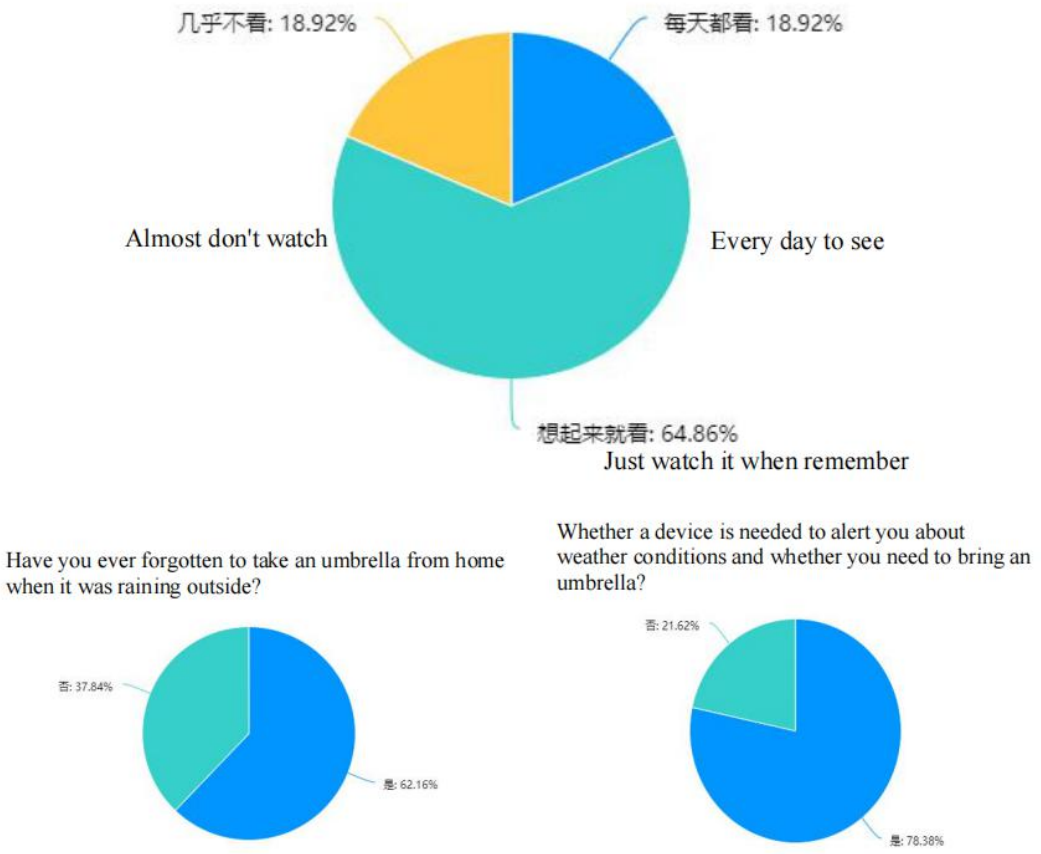


Figure 3: Questionnaire Results

Therefore, through the previous background research and questionnaire survey, we believe that the "intelligent umbrella stand" we want to develop is desirable in both practicability and rationality. If the product can be developed successfully, it can not only help us, but also solve the current confusion of many people and it will be very popular in the future.

1.2. Project Objective and Research Problem

Due to the background research, we think the main objective of our project is to design an intelligent umbrella stand using Raspberry Pi based on the design concept of the Internet of things. The product embeds a Raspberry Pi system that can remind people to take an umbrella when going out on rainy days. The whole intelligent umbrella stand will be placed at the door and when people approach it, the umbrella stand will automatically remind people to take an umbrella before going out. Once the product is designed successfully, people will no longer need to worry about a series of unnecessary troubles caused by going out in a hurry but forgetting to bring an

umbrella on rainy days. The key problem we need to consider is whether the intelligent umbrella stand can accurately remind people to take an umbrella on rainy days.

2. Prototype Design

2.1. Hardware Components

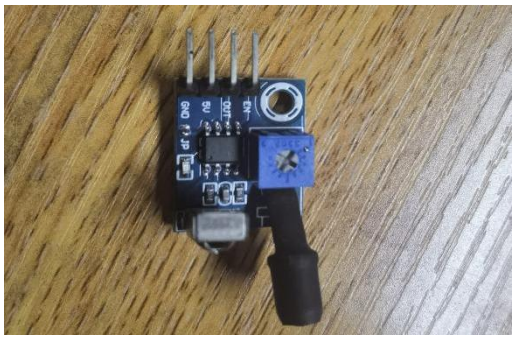
①Raspberry Pi 4B

Raspberry Pi 4B is an ARM-based mini-computer motherboard with SD/MicroSD card as the memory hard drive, card board surrounded by 4 USB interfaces and a 10/100 Ethernet interface (type A no network port), can connect the keyboard, mouse and network cable, while the video analog signal TV output interface and HDMI HD video output interface, the above components are integrated in a single and only slightly larger than the credit card motherboard, with all the basic functions of the PC (Cao et al., 2021). The intelligent umbrella stand project is based on the Raspberry Pi, which is made up of infrared sensors, HC-06 Bluetooth modules, active buzzers, LED lights, and audio.

②Infrared tube-to-tube sensor

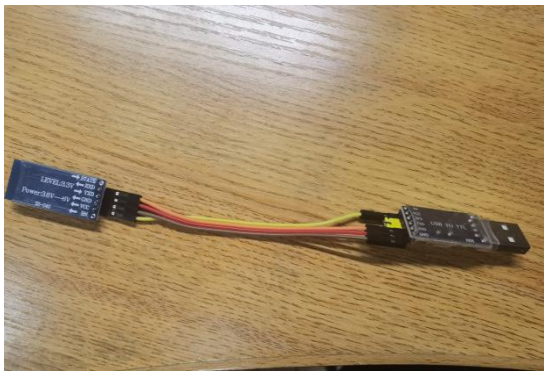
Infrared tube-to-tube sensor for the environment of the light adaptability is very strong. With a pair of infrared emission and receiving tube, transmitter will emit a certain frequency of infrared (Jiang & Li, 2020). When the direction of detection encountered obstacles, infrared reflection back to be accepted by the receiving tube. After the comparison circuit processing, the light will light up. We apply this sensor to human detection in our projects and use its sensing to trigger the reminder process of

our program.



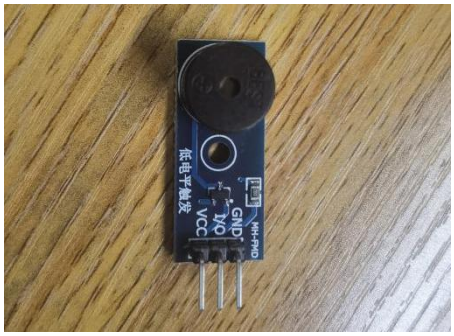
③HC-06 Bluetooth module

HC-06 is the main from the integrated Bluetooth serial module, the main command switch, the use of CSR mainstream Bluetooth chip, Bluetooth V2.0 protocol standard. We mainly use it to pair it with the mobile phone, using this Bluetooth module for data transmission between the mobile phone app and the Raspberry Pi.



④Active buzzer

Active buzzer relies on the principle of piezoelectric effect to make sound, there is a simple oscillating circuit inside, can be constant DC into a certain frequency of pulsed signal, so as to achieve magnetic field change, driving the sound of aluminum vibration. We use this active buzzer to act as a reminder to the user.



⑤LED light

Led light is mainly used to alert users. In the rainy day, when the human body through the infrared sensor is detected, LED light will light up to remind users to take an umbrella out of the door.

⑥Loudspeaker box and umbrella stand, etc

Loudspeaker box is mainly used for MP3 file playback, recorded MP3 file will be set when the conditions are met. The umbrella stand is made of rectangular plastic boxes, the interior of which is cut in half, half for Raspberry Pi and sensor placement, and half for placing umbrellas.

2.2. Relevant Technology

①Android System Development

Android system platform is developed by Google company. The system kernel itself is through Linux kernel, and the operating system belongs to embedded system (Leng, 2019). The Android platform is designed with the idea of hierarchical architecture. Its architecture has four layers from top to bottom. The top layer is the application layer handed over to users, then next is the application framework layer for the logical operation of the system, followed by the system library supporting the system operation and Android operation. The bottom layer is the Linux kernel. Android system is designed and implemented through Java programming language. The running of each program represents the realization of a process in the system. Through the parallel processing of multiple tasks, the performance of the system can

be improved. In our project, we have developed an Android app to send URL information corresponding to urban weather to Raspberry Pi through Bluetooth adapter.

②Web Crawler Technology

Web crawler technology, also known as web spider or web robot, is mainly used to collect all kinds of data and information. Web crawler is a key part of search engine. It can extract the content of specific pages on the Internet. Moreover, with the help of search engine web crawler work program, it is conducive to improve the efficiency of web data information acquisition and web data capture (Zhang & Xiao, 2021). Web crawler technology plays a very important role in our project. We will mainly obtain the weather data information corresponding to the web page through Python's Requests and BeautifulSoup library.

2.3. Project Development

2.3.1. Weather Data Platform

Because our intelligent umbrella stand needs to obtain urban weather data, we first need to find a suitable urban weather data platform before the whole project starts. Our first consideration is to use the Weather Underground website to obtain the weather data of the city, because this website is very powerful, which has very detailed weather information, and the API call is also very mature, with strong update and portability. In general, it is the most suitable for calling data and applying it to our intelligent umbrella stand development. Unfortunately, due to the paid API and we didn’t have much more money, we finally changed our plan and we chose to use the most authoritative China Weather Net platform in our country. It is the core portal for the China Meteorological Administration to provide meteorological information services to the public, integrating the latest meteorological business service products and timely and rich meteorological information of all business departments under the China Meteorological Administration. The China Weather Net is sponsored by the public meteorological service center of the China Meteorological Administration and carries out specific development, operation and maintenance. Figure 4 shows the

weather in Hangzhou on China Weather Net. On the whole, the weather update of China weather Net is very good and all the weather data information used in our project comes from this website.

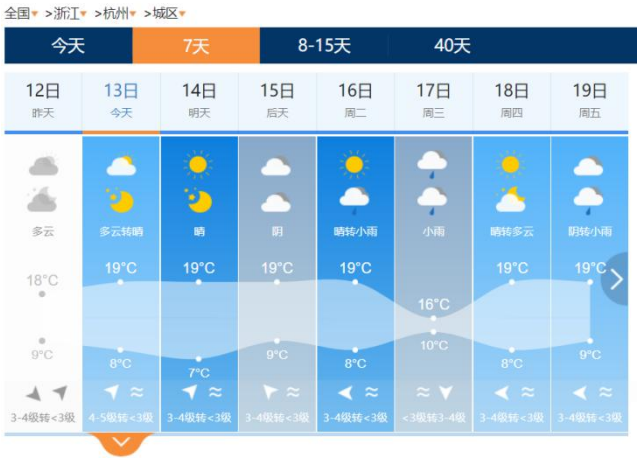


Figure 4: Weather in Hangzhou displayed by China Weather Net

2.3.2. Android App Development

Through the analysis of the website of China Weather Net, we have found that only thing different of each city is the URL code. For example, the URL code of Beijing is "101010100", while Hangzhou is "101210101". Therefore, we first input the URL code of the corresponding city in the Raspberry Pi terminal, and then the system can call the website to obtain the weather data of the corresponding city. However, after the experiment, we found that this scheme has a lot of trouble, because we need to manually control it through the Raspberry Pi terminal, which is very inconvenient in practical work. Therefore, our solution is to develop an Android app which can transmit the URL code of the city to Raspberry Pi, so that the Raspberry Pi can automatically call the city weather data from the corresponding website.

Figure 5 shows the overall layout of Android app and the principle of information transmission between app and Raspberry Pi. The connection between Raspberry Pi and app is realized through Bluetooth adapter. When users use the app, they need to configure Bluetooth first. When the Bluetooth connection is successful, they can use app to transmit information to the Raspberry Pi. At the same time, in order to facilitate our use of the system, we have set the "Hangzhou" and "Chongqing" buttons respectively, which are the two cities we commonly use and we

have set the URL coding interface for them in advance. After clicking these two buttons, the app will automatically transfer the URL code information to the Raspberry Pi, instead of querying the URL code information again every time we log in to the app. For other cities, users need to input the URL code of the corresponding city, so as to transmit relevant information to Raspberry Pi and call the weather data of the corresponding city.

Through the development of this app, users can remotely control the intelligent umbrella stand by operating the Android app. Compared with the previous manual control on Raspberry Pi, this scheme will be much more convenient.

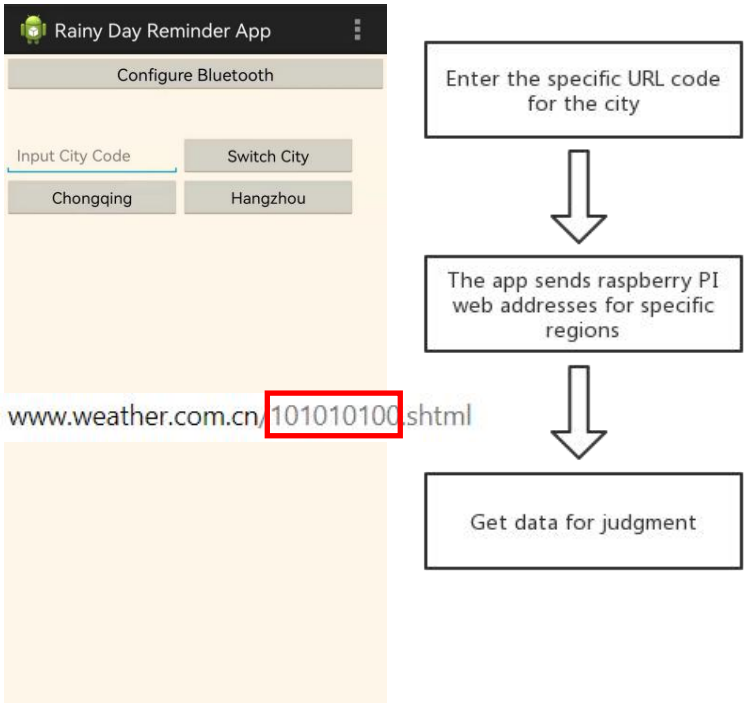


Figure 5: App layout and the working logic

2.3.3. Working Principle of the Whole Project

Through the early analysis of the hardware and relevant technologies, we draw the network map of the intelligent umbrella stand project. As shown in Figure 6, Raspberry Pi is connected with the web server through WiFi, so that the corresponding urban weather data can be obtained from the website of China Weather Net. After obtaining the data, the Raspberry Pi will send instructions to the relevant hardware according to the actual situation of the program, and the hardware will run according to the instructions, so as to realize the interaction between the Raspberry Pi

and the hardware. At the same time, Raspberry Pi and Android app are connected through Bluetooth adapter, so that Raspberry Pi can monitor the information sent by app and carry out corresponding operations.

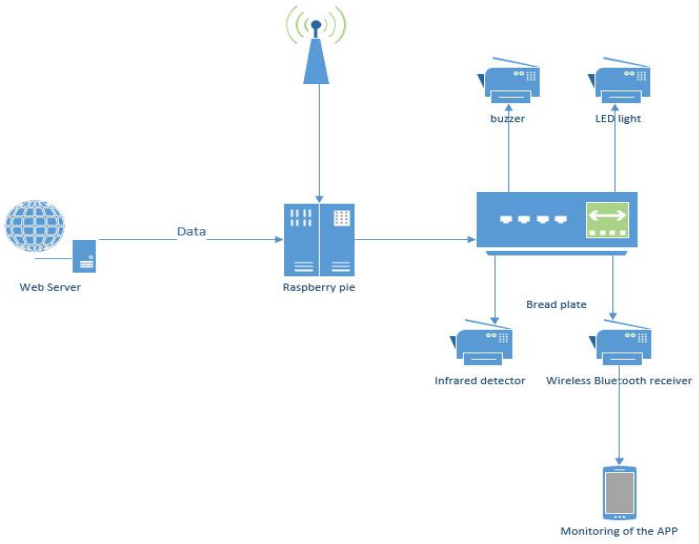


Figure 6: Network Map

According to the network map, we finally realized all the functions of our intelligent umbrella stand project. We use Python to write the core code of the project. In the whole project, the core is the implementation of web crawler. Figure 7 shows the core code of web crawler part. We have defined the getHtmlText and makeSoup functions. The function of getHtmlText is to use Python's “requests.get()” method to obtain the URL address of the website. The makeSoup function is used to capture the urban weather data of web pages by using Python's BeautifulSoup library. The BeautifulSoup library can automatically convert the input document into Unicode and the output document into UTF-8, which is convenient for subsequent processing using Python3. At the same time, after obtaining the data, it will classify and automatically discuss the results. If there is word "Rain" in the obtained data and the infrared sensor detect the object, the relevant hardware will work to remind people to take an umbrella when they go out on rainy days. Without the word “Rain”, the relevant hardware will not work.

```
def getHtmlText(url,code='utf-8'):
    try:
        r = requests.get(url)
        r.raise_for_status()
        r.encoding = code
        return r.text
    except:
        return ''
def makeSoup(html):
    wstr = ''
    #print html
    if html == '':
        return "I don't know the weather in Hangzhou today"
    else:
        soup = BeautifulSoup(html,'html.parser')
        soup1 = soup.find_all('li',attrs = {'class':'on'})[1]
        str1 = re.findall(r'>(.*)</',str(soup1))
        b = ''
        try:
            slist = re.findall(r'^(.*)</span>(.*)<i>(.*)$',str1[4])

            #print slist
            for x in range(len(slist[0])):
                b += slist[0][x]
        except:
            b = str1[4]
        if '/' in b:
            b = b.replace('/','-')
        str1[4] = '!Temperature:'+b
        str1[6] = '!WindSpeed:'+str1[6]
        if '&lt;' in str1[6]:
            str1[6] = str1[6].replace('&lt;','!')
        for i in str1:
            if i != '':
                wstr = wstr +i
        if '雨' in wstr:
            wstr += "Don't forget to take the umbrella today!"
            serVB.write('w1')
            GPIO.output(LEDPin, GPIO.HIGH)
            GPIO.output(Speaker, GPIO.LOW)
            os.system('mplayer 123.mp3')
        print(wstr)
        return wstr
```

Figure 7: Core Code

By solving the core problem of web crawler, the working principle of our whole intelligent umbrella stand project can be clearly shown. Figure 8 shows the working principle of our whole project. First of all, Android app sends instructions to Raspberry Pi, and then Raspberry Pi calls the program and uses web crawler technology to obtain the weather data of the corresponding city from China Weather Net according to the URL code sent by the app. After obtaining the data, it judges the result. If there is the word "Rain" in the result text, when the infrared sensor senses people approaching, the buzzer, LED light and loudspeaker box will work, and Raspberry Pi will output weather information. If there is no word "Rain", when the

infrared sensor senses people, it will only output information on Raspberry Pi, and the corresponding hardware will not work.

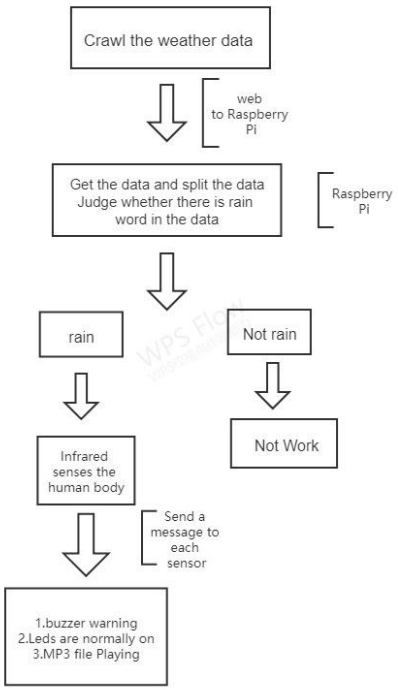


Figure 8: Working principle of the whole project

2.3.4. Final Prototype

Our final prototype is shown in Figure 9. The picture on the left part shows the core hardware of our Raspberry Pi. The whole hardware part consists of Raspberry Pi 4B, Infrared tube-to-tube sensor, HC-06 Bluetooth module, Active buzzer, LED light and Loudspeaker box. In rainy days, if the infrared sensor senses people passing by, the buzzer will alarm, the LED light will turn on, and an MP3 voice will be released in the loudspeaker box to remind people to take an umbrella when they go out on rainy days. The audio output of Raspberry Pi is realized by inputting “amixer” command at the Raspberry Pi terminal. The umbrella stand is made of rectangle plastic box, which is cut into two halves, one half used for placing Raspberry Pi and relevant hardware, and the other half is used for placing umbrellas. The umbrella stand is separated by foam board in the middle, so that the Raspberry Pi and relevant hardware can be embedded into the umbrella stand to realize intellectualization, and at the same time, it can avoid damaging the hardware by rain.

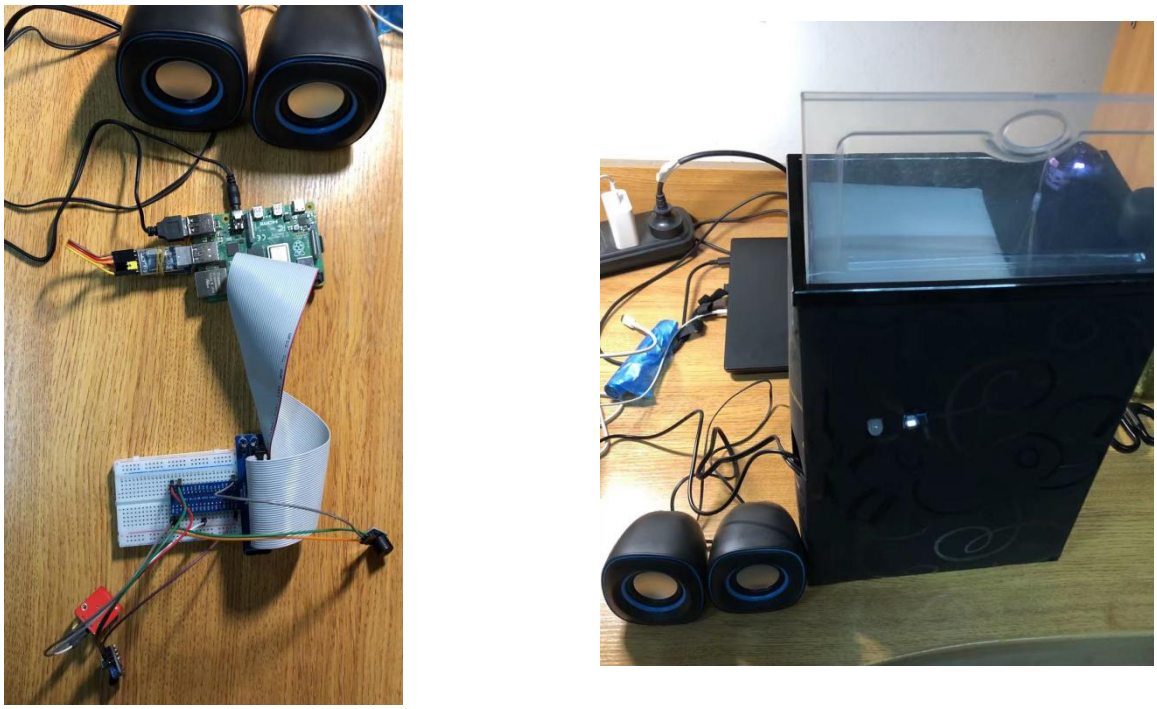
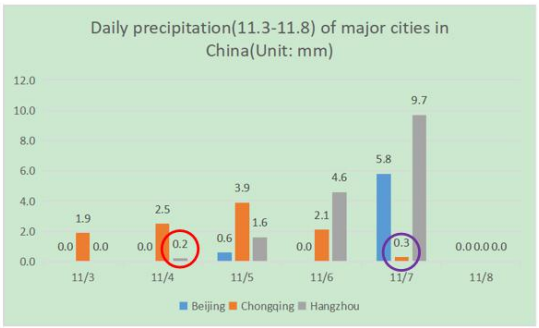


Figure 9: Final Prototype

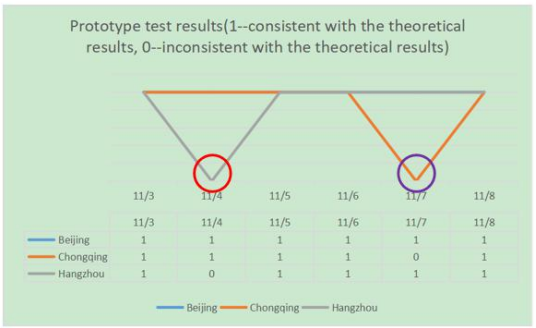
3. Data Collection and Analysis

First of all, because the most important thing of our intelligent umbrella stand project is to realize the function of reminding people to take an umbrella when going out on rainy days, we first need to test the accuracy of our prototype. In order to make the test more accurate, we used our prototype to test the weather of 3 major cities in China. We tested at 8 a.m. every day, mainly considering that it is the time when many people go out to work. Figure 10 shows the test results of this part of data. We compare the test results with the daily precipitation which got from China Weather Net and we have tested the data for a total of 6 days from November 3rd to 8th. In the right part of Figure 10, "1" represents that the test results are consistent with the theoretical results, and "0" represents that the test results are inconsistent with the theoretical results. We found that two data are inconsistent with the theoretical results, one is the weather in Hangzhou on November 4th, and the other is the weather in Chongqing on November 7th. By comparing with the actual precipitation of the city on that day, we found that the precipitation of the corresponding city in these two days was less than 0.5mm. We speculated that the inaccurate results may be due to the

short-term heavy rainfall in the city on that day, which led to the inaccurate data test. In this regard, we still need to further improve our prototype in the future.



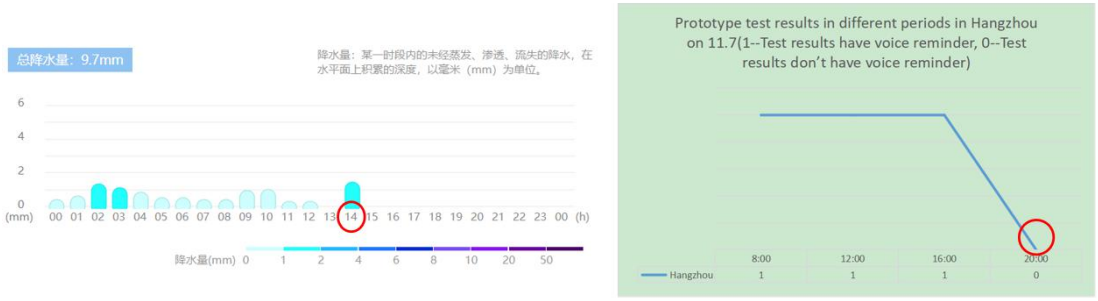
Daily precipitation of major cities in China



Prototype test results

Figure 10: Data collection 1 results

In addition, because the weather is real-time, our second data is to test the real-time performance of our prototype. We used our prototype to test the weather in Hangzhou at different times in November 7th. Figure 11 shows our test results of this part of data. The left part of Figure 11 shows the hourly precipitation in Hangzhou on November 7th. This part of data is obtained from China Weather Net for comparison with our test results. The right part shows our test results. From the figure on the right part, "1" represents that the test results have voice reminder, which means the weather is rainy and the prototype reminds people to take an umbrella when going out. "0" represents that the test results don't have voice reminder. After testing, we found that at 8 p.m. on that day, the umbrella stand no longer reminds people to bring umbrellas when going out. We think it's because it would not rain in Hangzhou after that time, so there was no voice reminder. In contrast to the left part, we can find that on November 7th, there was no rain after 2 p.m. in Hangzhou, so the test result at 8 p.m. was accurate without voice reminder. After the testing, we can see that our prototype has a certain real-time performance. However, in general, the real-time performance of the prototype is not perfect, because the data we obtained can not be updated every hour, which still makes some errors in real-time performance. For example, at 4 p.m. on that day, in theory, the test results will not have the voice reminder, but in the end, they are inconsistent with the theoretical results. Therefore, we still need to further improve the real-time performance of the prototype in the future.



Distribution map of hourly precipitation in Hangzhou on 11.7

Prototype test results in different periods in Hangzhou on 11.7

Figure 11: Data collection 2 results

4. Market Comparison

4.1. Disadvantage of the Existing Solution

After the completion of the whole project, we first need to analyze the business prospect of our intelligent umbrella stand project. We compared our project with the existing solutions in the market and analyze the advantages and disadvantages of relevant solutions. To solve the problem that people forget to bring umbrellas when they go out on rainy days, there are two main solutions in the market, one is the shared umbrella mode, and the other is the smart umbrella (e.g. Oombrella)

①Shared umbrella mode

Shared umbrella refers to the shared services provided by enterprises in subway stations, commercial areas, residential areas, campuses and hotels. It is a new form of sharing economy. As far as shared umbrella mode is concerned, although in recent years, the market for shared umbrella has developed rapidly and has a good market base, it still has many defects. First of all, the deposit for sharing an umbrella is usually around 20 yuan, which can usually be purchased directly for a new umbrella. Secondly, the problem of difficult to withdraw or non-refundable deposit under the shared mode occurs frequently, which makes many consumers resistant to use the shared umbrellas. Apart from that, shared umbrella is poorly maintained and the sites are very scarce. Due to the lack of appropriate regulatory mechanisms, many umbrella-sharing sites are damaged, unable to use normally on rainy days.

②Smart umbrella(e.g. Oombrella)

For the smart umbrella, it is very powerful because it is equipped with ultrafast local weather data identification and tracking functions, and can wirelessly connect to the mobile phone and send reminder information. However, it's very expensive. An umbrella costs about $75, and few consumers will pay such a high price just for an umbrella. On the other hand, many consumers just want to buy an umbrella that can take shelter from the rain. For them, if the use of the umbrella is too complex and the functions are too redundant, it will be very troublesome.

4.2. The Advantage of Our Project

Compared with the current solutions above, we believe that our intelligent umbrella stand project has the following commercial advantages.

①Perfectly in line with consumer needs

The intelligent umbrella stand has the ability to remind people to take an umbrella when going out on rainy days, which is exactly what many people need.

②Strong practicability

The intelligent umbrella stand designed by us has small volume and more practical function. It is suitable to be placed at the entrance gate. At the same time,

considering the function of the intelligent umbrella stand, it is a good choice for consumers to use at home.

③Low Economic Cost

In contrast to the current solutions, our intelligent umbrella stand costs less. The whole cost is about 350 yuan, which has a great price advantage. Compared with the shared umbrella mode, users can directly take out their umbrellas and use them without looking for the shared umbrella website, which has high timeliness.

4.3. Result

According to the above analysis, our intelligent umbrella stand has a good business prospects, which can be widely used in consumer homes, hotels and other areas. At present, there are no similar products with low price and strong practicability in the market, which is a major competitive advantage of our project. However, there are still some shortcomings, such as the lack of umbrella slot and poor real-time performance. These are what we need to improve in the later stage.

5. Limitation and Future Development

5.1. Limitation of the Project

Our whole intelligent umbrella stand project has realized the function of reminding people to take an umbrella when going out on rainy days and generally, it has good accuracy and real-time performance. However, through analysis, we still found that our project has some following limitations:

①The effective sensing distance of infrared tube-to-tube sensor is 2 to 30cm, and the maximum effective sensing angle is about 35 degrees. After testing, when the distance exceeds its effective distance or exceeds its maximum detection angle, it is difficult for the sensor to detect the user. In addition, the detection principle of the infrared tube-to-tube sensor is that after the transmitting tube emits, the infrared is received by the receiving tube and triggers the indicator after encountering the reflection of obstacles. Therefore, in the test, we found that when the umbrella stand is placed irregularly, not only the human body, but also some obstacles will cause the alarm

mechanism to trigger the buzzer.

②When we need to switch cities on the app, we must know the URL code for the corresponding city before the app can send the URL code to the Raspberry Pi, which is combined into the correct website to crawl the corresponding weather data. This setting greatly increases the user's inconvenient operation.

③Our intelligent umbrella stand is made up of a whole plastic box, half of which is used for Raspberry Pi and relevant hardware, and the other half for placing umbrellas. But we didn’t take into account the use of umbrellas after rainy days, when there is often a lot of rain left on the umbrella surface, which can easily lead to the accumulation of rain in the umbrella stand and it will impact the work of Raspberry Pi.

④The intelligent umbrella stand weather data is from the China Weather Net, using python to crawl. However, the weather data on the China Weather Net only updated at a fixed time period, which makes it difficult for us to obtain real-time weather data, especially in the summer when we are prone to short-term heavy precipitation, which will have an impact on the use of our device.

5.2. Project Future Development

According to the above project limitation analysis, We think we can take the following measures to improve our intelligent umbrella stand project.

①Replace the infrared tube-to-tube sensor with an Passive Infrared Ray (PIR), which can detect infrared emissions from the human body and convert them into electrical signals for output. Compared with the traditional infrared tube-to-tube sensor, the PIR's detection angle is wider, the widest angle can reach about 120 degrees, and the detection distance for the human body is farther, the horizontal sensing distance can reach 5 meters, which can greatly improve the detection range and reduce the number of false positives.

②For the problem that every time we need to input the URL code in the Android app, first of all, we plan to add a GPS module to the Raspberry Pi, which can determine the corresponding city location through GPS positioning and automatically adjust the city

location. Secondly, we plan to establish a URL database for each city in the app, and each city has its own unique URL code. By searching cities, users can greatly improve their efficiency.

③As the intelligent umbrella stand may accumulate water, we plan to make a water collecting tank for pumping water and set a water level sensor in the tank. When the water level reaches a certain height, Raspberry Pi will send a reminder message to the application to remind users to empty the tank in time.

④In order to improve the data timeliness of intelligent umbrella stand, we have two improvement measures. First of all, we plan to collect data from multiple meteorological stations in the same city and use the latest meteorological data after multiple data comparisons. The second is to use the real-time weather forecast system platform.

6. Conclusion

Currently, our intelligent umbrella stand project has implemented most of the planning functions, including hardware design and connectivity, programming for Raspberry Pi, and development of the project-related Android app (for urban area switching). After necessary testing and experimentation, the project can run for long period of time and is used normally in special environment.

The basic logic of our project implementation is to crawl the weather data through the program. When the infrared tube-to-tube sensor senses the human body, the program will judge by capturing data. If it rains outside, it will drive the buzzer and LED light to work, and play MP3 file at the same time.

Through the research of the whole project, we have mastered how to switch data using Python's crawl of website data, the basic use of Raspberry Pi, the use and line connection of the corresponding hardware sensors, and how to switch between Bluetooth and app connection. At the same time, we have a deeper understanding of the relevant design concepts of the Internet of things. However, our project still has a lot of shortcomings, for example, the reminder rate of real-time weather data

acquisition is low, which may have a certain lag. At the same time, the sensing distance of the infrared tube-to-tube sensor is short, and there is no rain water tank.

But in general, the whole project is quite successful. Our team members work together tacitly and everyone can complete their own work. All in all, this is a very meaningful experience in our daily study.

Appendix: Member Roles in the Whole Project

Our whole “Intelligent Umbrella Stand” project can be divided into several parts, and each part is in the charge of designated team members. Tianyang Li is the group leader, assigning and coordinating the work of group members and the project process. The specific division of labor is as follows:

①**Background Research (including questionnaire survey):** Tianyang Li, Shijie Ma

②**Market Research:** Hanpeng Jiang, Jiacheng Lv

③**Prototype Design:**

(1) Hardware Acquisition: Jiacheng Lv

(2) Prototype Design(Raspberry Pi hardware assembly+embed in umbrella stand): Hanpeng Jiang, Jiacheng Lv

(3) Raspberry Pi Programming: Tianyang Li, Shijie Ma

(4) Android app Programming: Tianyang Li

④**Prototype Testing and Data Collection:** Tianyang Li, Shijie Ma

⑤**Prototype Video Demo Shooting:** All group members

⑥**Presentation ppt Production:** All group members

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