DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

EEE311 FINAL YEAR PROJECT

Intelligent System for Smoking Cessation and Health Tracking

Final Thesis

In Partial Fulfillment

of the Requirements for the Degree of

Bachelor of Computer Science

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Abstract

Various smoke cessation methods have been widely applied to facilitate smokers to quit the habit. However, most of them focus on breaking nicotine addiction rather than breaking psychological addiction. On the other hand, current portable health analysis devices provide less health-related information that associated with smoking. Therefore, a portable health analysis device designed for smokers and a psychological smoking cessation therapy are needed. On the basis of the cognitive behavioral therapy method, photoplethysmography technique, Internet of things technique and website development technique, a system consisting of a portable device and a website has been developed under need.

Keywords: Psychological therapy; m-health; website development; Internet of Things; smoking cessation; portable device

Acknowledgements

First and foremost, I would like to show my deepest gratitude to my supervisor Dr. Liu Qing, who has provided me with many valuable advices and adequate guidance. She not only provided me with novel perspectives in health analysis field, but also taught me some specific research skills through enlightening instruction. During the whole development process, she has always been patient and gave me constant support. Then I want to extend my thanks to Dr. Kim, who kept following my project progress and encouraging my working, even in this difficult time. Besides, special thanks go to my family and my girlfriend. They provided me with warm company, and kept inspiring me when I felt down. Finally, I want to thanks myself for the constant commitment to excellence.

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1. Introduction

1.1 Motivation and Objective

1.1.1 Motivation

Smoking is one of the leading causes of deaths and many diseases. According to the World Health Organization`s (WHO) estimates in 2014, 5 million people were killed by smoking every year [1]. Nevertheless, it is hard for smokers to quit smoking relying on their psychokinesis and existing representative smoking cessation methods are all developed to help smokers get rid of the Nicotine addiction. Therefore, a psychological therapy is needed to help smokers quit the habit efficiently. Besides, only the minority of smokers can have a thorough medical examination frequently, which is not convenient. And current portable devices are not designed for smokers, which contain less information that smokers concerned about. Thus, a portable device designed for smokers is demanded.

1.1.2 Objective

This project aims to develop a system, that helps smokers get rid of the psychological addiction through CBT (Cognitive Behavioral Therapy) and allows users to track their health condition through portable device. The study consists of four main aspects, which are portable device development, health analysis algorithm design, website development and IoT technique application. In user's perspective, there are two components of the system: portable device and website. To be more specific, establishing a portable device to measure users' physiological signal. Realizing health analysis algorithm to process the raw data and acquire meaningful analysis results. Implementing the IoT technique to build the communication between the portable device and website. Developing a dynamic, interactive and self-adapting website to display the psychological therapy and combined with IoT technique allows users tracking their health analysis result in real-time.

1.2 Literature Review and Discussion

1) Stephen R. Alty and Natalia Angarita-Jaimes conducted a study named "Predicting Arterial Stiffness From the Digital Volume Pulse Waveform" in 2007 [2]. They indicated that the crest time, stiffness index (SI) and pulse propagation time are with good performance when used for vessel assessment, for their close relationship with PWV (pulse wave velocity). Crest represents the rise time shown in Figure 2 (b), and SI is calculated from $\mathrm{SI} = \frac{\mathrm{H}}{\Delta \mathrm{T}}$. Where $\Delta \mathrm{T}$ is the pulse propagation time shown in Figure 2 (b), and H is the height of testee. The study also indicated that compared with healthy subjects, the crest time of subjects with arterial sclerosis is longer. Meanwhile, this study stated that it is possible to do cardiovascular health assessment with high quality quickly through patients' DVP waveform only.

   This research proves the feasibility that using pulse-wave analysis smokers' vessel health through extracting feature point from pulse wave. Besides it also provides the health analysis process of this project with a guide on cardiovascular health assessment direction. However, it lacks of the statistical data analysis on the relationship between arterial sclerosis and the index value.

2) Q. Yousef, M. B. I. Reaz and M. A. M. Ali conducted a study in 2012, which focus on the analysis of PPG morphology [3]. To be more specific, the relationship between some health standard with the specific PPG morphology, especially arterial compliance, was studied. During study, two indicators reflection index (RI) and stiffness index (SI) were applied for vascular assessment. RI is inferred from the values of systole peak and diastolic peak and SI is calculated from PPT and both of them were proved to be reliable. Calculation details will be in section 3. The conclusion is given as a window to cardiovascular activities is provided by PPG AC component analysis, and the indicators have remarkable relation with vascular state.

   To some extent, this study supports the perspective of the previous research. However, compared with the previous study, it introducing the statistical data analysis to support its perspective. Although, this study provides a viable method to assess vascular, it lacks of the comprehensive analysis of pulse wave.

3) Nivedita Daimiwal, M. Sundhararajan and Revati Shriram conducted a study named “Respiratory Rate, Heart Rate and Continuous Measurement of BP Using PPG” in 2014 [4]. During the study, fast Fourier transform was applied for spectrum analysis to obtain respiratory rate and heart rate. The study indicated that the blood pressure can be estimated by the relationship between peak height and the SBP (systolic blood pressure) as well as DBP (diastolic blood pressure) correlation coefficients.

   The study relatively makes full use of the health-related information hidden in pulse wave and provide a new perspective of pulse wave analysis that spectrum analysis. Besides this study also provide a feasible method to estimate blood pressure. However, the correlation coefficients cannot be obtained by PPG signal which is a small defect and the analysis of each health-related index is not sufficient.

4) D. Deepak Gautam and V. K. Giri conducted a research named "Analysis of HRV signal for disease diagnosis" in 2016 [5]. This study introduced the relevant information about heart rate variation (HRV) and indicated both the time domain and the frequency domain analysis method for HRV. This study also compared the value of normal HRV index with exceptional HRV index value.

   The study has made relatively sufficient analysis on HRV, which has directive effect to this project in HRV analysis

5) Abdullah H. Alsharif and Nada Philip conducted a study named “Cognitive Behavioural Therapy embedding smoking cessation program using smart phone Technologies” in 2015 [6]. During this research a new approach of combining smartphone and CBT (Cognitive Behavioral Therapy) methods to provide an effective smoking cessation program was presented. The convenience and ubiquitous presence of smartphone were utilized to provide a CBT paradigm in smoking cessation application.

   This study proves that the CBT is practicable to help smoker quit the habit, and it made a meaningful trial in combining the smartphone technique and CBT method. This study plays an instructional role in the psychological therapy page development process. However, the result of

this study has some drawbacks, such as it is lack of the functional module, the interface is limited by the size of smartphone and it does not provide any health-related information.

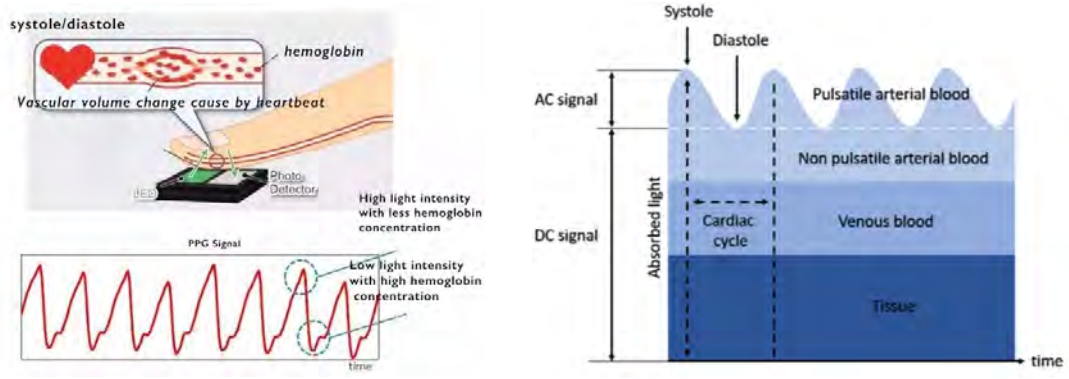
6) Christos Maramis and Vasiliki Mylonopoulou conducted a project named “Developing a Smartphone Application to Support Smoking Behavior Change through Social Comparison” in 2019 [7]. Based on up-to-date BCS (Behavior Change Science) theory and adopting the user-oriented design, a novel smartphone application named QuitIT was developed. QuitIT allows the user keep tracking their cigarette consumption and facilitates smoker quit the habit by compare their daily cigarette count with others. The pilot study done in this project, shows that the QuitIT has a good effect on smoking cessation and BCS can be combined with portable device.
   This study enlightens the functional module design of the website and also proves the feasibility of applying functional module to motivate smokers to stop smoking. Besides, inspired by the study, this project also adopted the iterative user-centered design methodology [8].

7) D. Williams et al conducted a research named “Building a Tailored Text Messaging System for Smoking Cessation in Native American Populations” in 2018 [9]. The study indicated modular customized message with conversational tone can facilitate people live in a happy and healthy lifestyle. Besides, the research also claimed that an automated chat system can enhance the positive effect seen in the study, and will have lower cost.
   On the basis of this study, an intelligent assistant is developed in this project, which serves as an automated chat system.

1.3 Relevant Knowledge

1.3.1 Photoplethysmography technique

PPG is widely applied for assessing vessel compliance [10], calculating body oxygen level [11], obtaining heart rate and respiratory rate [12]. Compared with the other two traditional pulse signal extraction method that extract from ECG (Electrocardiograph), calculate from fluctuation of blood pressure, PPG technique has been widely used due to its portability, flexibility and accuracy. PPG utilizes the character that the light absorption rate of blood vessel will change with its blood content to transform the heartbeat related variation of blood concentration to reflected light intensity, which provide investigator a window to observe the invisible information. PPG sensor is consisted of a group of light sources and a photodiode. To be more specific, green, red and IR LEDs are applied as light sources due to human physical characteristics, and photodiode is applied to detect reflected light and transform it into electronic signal which will be converted to digital signal further. Working principle of PPG technique is shown as Figure 1 (a). PPG signals are consisted of two ingredients that AC component and DC component. DC component is attributed to the body composition with constant absorption rate such as tissues, venous capillary as well as venous blood [13]. AC component ascribe arterial blood concentration variation with each heartbeat [14]. The compositions of PPG signal is shown as Figure 1 (b).



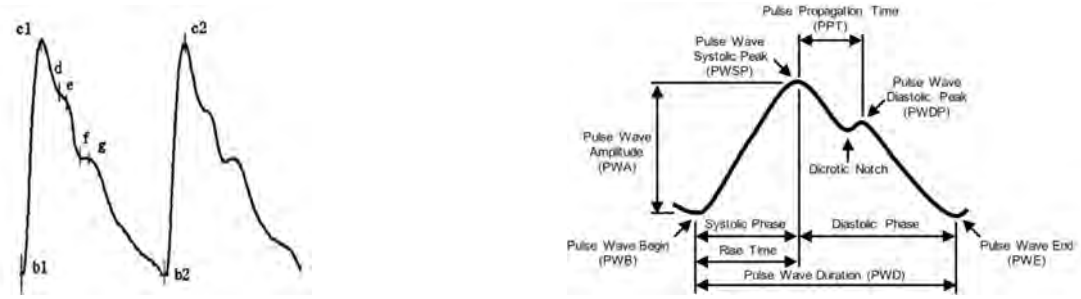
(a). Working Principle of PPG (b). PPG Signal Compositions

Figure 1: PPG Introduction

The peripheral pulse of PPG is often applied to assess health condition [15]. **Note that** the PPG signal is actually the emergent light intensity which is reversely proportional with the arterial blood concentration.

1.3.2 Pulse Wave

The contour of PPG signal is pulse wave. Pulse signal is generated by the procedure that cardiac impulse actuate blood to flow along vessels, thus it is considered as the external reflection of cardiac internal motion state by current science perspective. During the propagation process that from heart to the whole arterial system of pulse wave, the pulse wave will not only be influenced by cardiac motion, but also will be affected by the physiological status of arterial system such as vascular elasticity, vascular hardness, blood viscosity and so on. Therefore, there are many health-related information contained in pulse signal [16].



(a). Feature points (b). Characteristics stage [17]

Figure 2: Pulse Wave Diagram

As shown in Figure 2 (a), there are six primary feature points in a period of pulse To be more specific, b1 is considered as the patulous point of aorta valve, c1 is regarded as the maximum pressure point during systole stage, d represents the aortectasia depressurization point, e refers to the beginning point of left ventricular diastolic phase, f is identified as dicrotic notch and g is treated as the maximum pressure point of dicrotic pulse. Except these features, there still are several meaningful characteristics during a period of pulse wave (as shown in Figure 2(b)). The whole period of pulse wave can be mainly divided into two phase that, diastolic phase and systolic phase. Besides, systolic phase changes with a small range in the inverse direction of heart rate variation, which means the change of PWD is mainly related to dicrotic phase [18]. Additionally, the PPT (pulse propagation time) is an important indicator. To be more specific, PPT is the time between systole stage peak and dicrotic pulse peak that is attributed by blood backflow. For the health analysis procedure of this project, the feature points b1, c1, g and characteristics stage PPT are applied for calculating and health analyzing. Meanwhile the health criterions are established on the basis of the situations mentioned above.

1.3.3 Django Framework

Django is a mainstream website development framework for Python which emphases the code reuse, functional module decoupling and regard each component as an add-in to let them provide service to the whole framework conveniently. Django adopts MVT (Model, View and Template) pattern as shown below:

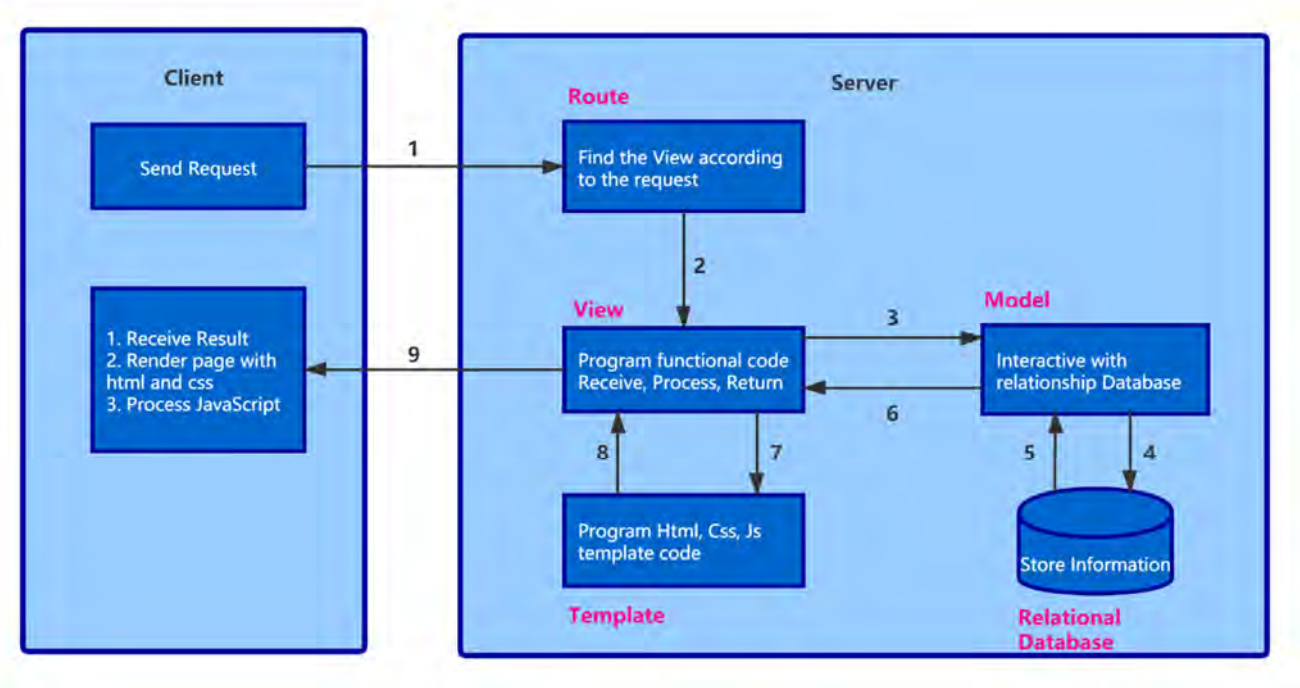


Figure 3: MVT Pattern of Django

View, Model, and Template are three core components of Django. View is the place to program functional module such as data monitoring script and Template file is used to store the html file which implement the front-end design. There are still some important modules and files in the Django:

Django Modules	Function Description
view.py	In charge of business logic. Call Template and Model
model.py	In charge of business object and database object
url.py	Route configuration file. Direct the request to the correct function in view.py
setting.py	Project configuration file. Global control file
manage.py	Project management file
wsgi.py	Web Server Gateway Interface

Table: Modules Description of Django

Django File	File Description
Template file	Store the html file which Implement the front-end design
Static file	Store the static resources such as .css, .js, .mp4 or .jpg files

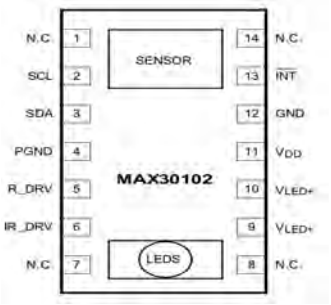
Table 1: Files Description of Django

3. Methodology

3.1 Health Analysis

3.1.1 Hardware Description

MAX30102 developed by Maxim company is applied for serving as PPG sensor that mentioned in literal review, which is consisted of LEDs, photodetectors, optical elements and low-noise electronics with ambient light rejection. For this module, infrared ray LED and red LED are integrated. Note that the photodetector will obtain the data representing the reflected light intensity, which come from both two LEDs. Through standard I2C compatible communication interface, the measured data can be transferred to the stm32, Arduino and other single chip microcomputer to do further algorithm process.



PIN	NAME	FUNCTION
1, 7, 8, 14	N.C.	No Connection. Connect to PCB pad for mechanical stability.
2	SCL	I²C Clock Input
3	SDA	I²C Data, Bidirectional (Open-Drain)
4	PGND	Power Ground of the LED Driver Blocks
5	R_DRV	Red LED Driver.
6	IR_DRV	IR LED Driver.
9	V_{LED+}	LED Power Supply (anode connection). Use a bypass capacitor to PGND for best performance.
10	V_{LED+}	
11	V_{DD}	Analog Power Supply Input. Use a bypass capacitor to GND for best performance.
12	GND	Analog Ground
13	INT	Active-Low Interrupt (Open-Drain). Connect to an external voltage with a pullup resistor.

Figure 4: MAX30102 Pin Diagram and Function Description

On the basis of the MAX30102 module, HXDZ-30102-ACC is adopted to measure body signal in this project. HDXZ-30102-ACC can detect and record the in-motion data by introducing the acceleration sensor. Besides, the MAX30102 is placed on the back of the PCB separately to decrease the interference and improve the result accuracy.

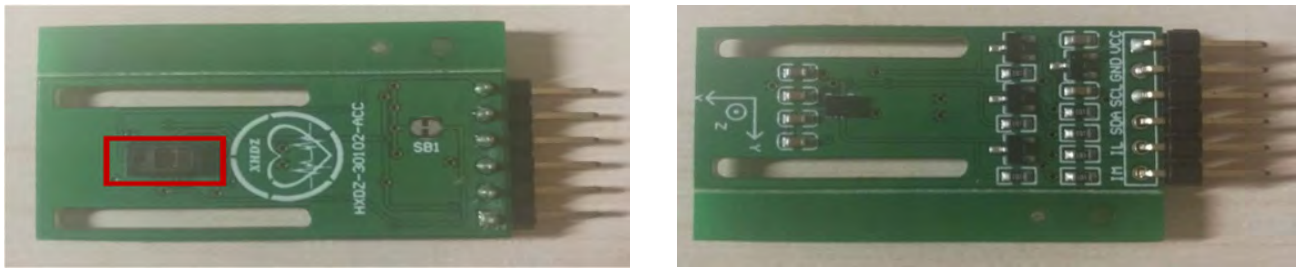


Figure 5: HXDZ-30102-ACC

VCC is the power input end and the Pull-Up level of I2C bus. **GND** is the ground line. **SCL** is the clock signal line of the I2C bus and **SDA** is the data signal line of the I2C bus. **I_L** is the interrupt pin of the acceleration sensor and the **I_M** is the interrupt pin of MAX30102 module.

3.1.2 Signal acquisition (First Version)

In the first version, an upper-computer software developed by Maxim company is applied as a serial assistant, which is used for acquiring original data, setting appropriate data collection parameters, as well as saving data for further analysis.

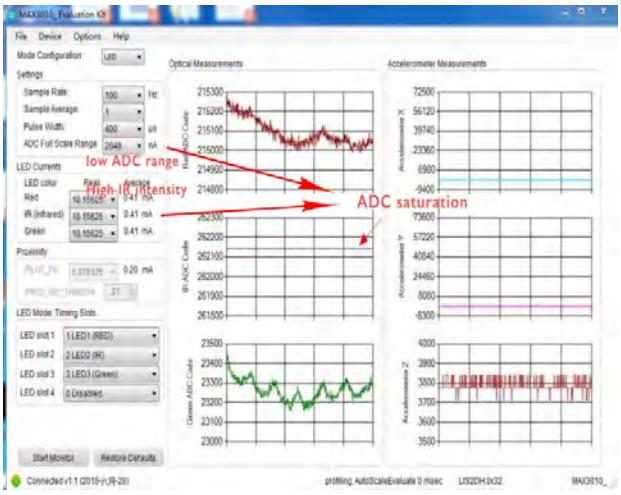


Figure 6: Upper-computer Software (Applied in First Version)

To obtain precise and correct data, appropriate parameter setting is necessary. **ADC full scale range** is a significant parameter, low ADC full scale range may cause analog to digital converter in saturated state (shown in Figure 5), which will lead to wrong feedback value. Actually, after doing multiple experiments, the values of PPG signal are supposed to at the scope 1/3 of ADC range to 1/4 of ADC range. Meanwhile, to enhance signal-to-noise ratio, appropriate **LEDs light intensity** are essential. In the third place, on account of finger PPG is widely applied in practice and is easier to recorded, **PPG signal measurements were done on index of fingers** (as shown in Figure 5) [19]. Finally, the original data is saved on computer. Note that by introducing a Bluetooth module, the data can be sent to either computer or smart phone. The Measurement procedures are shown as Figure 6.

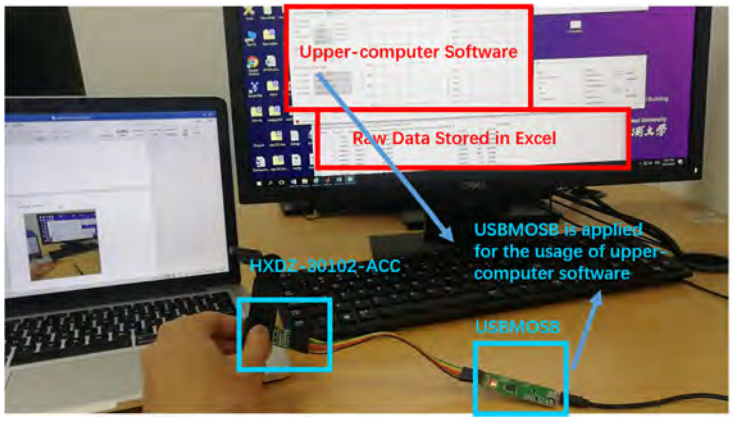


Figure 7: Measurement Procedures

3.1.3 Signal acquisition (Current Version)

In this version, the upper-computer software is replaced by the health analysis result subpage of the website (as shown in Figure 7), Python monitoring program, and MQTT server. To be more specific, the subpage is applied to show the PPG signal in real-time, Python monitoring program is used to store the raw data and MQTT server serves as an intermediate message media.

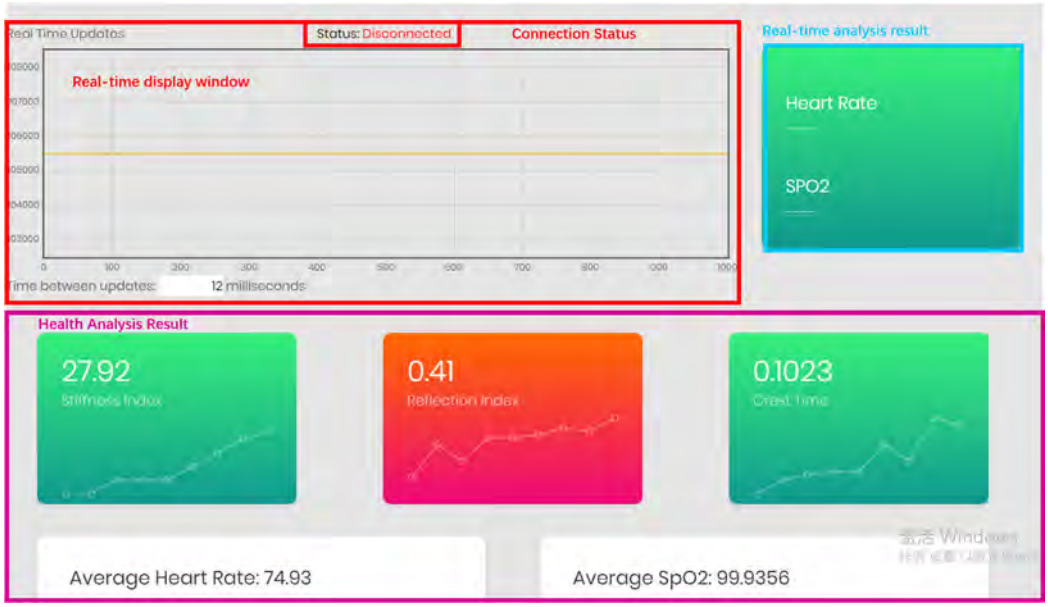


Figure 8: Health Analysis Result Subpage (Used in Current Version)

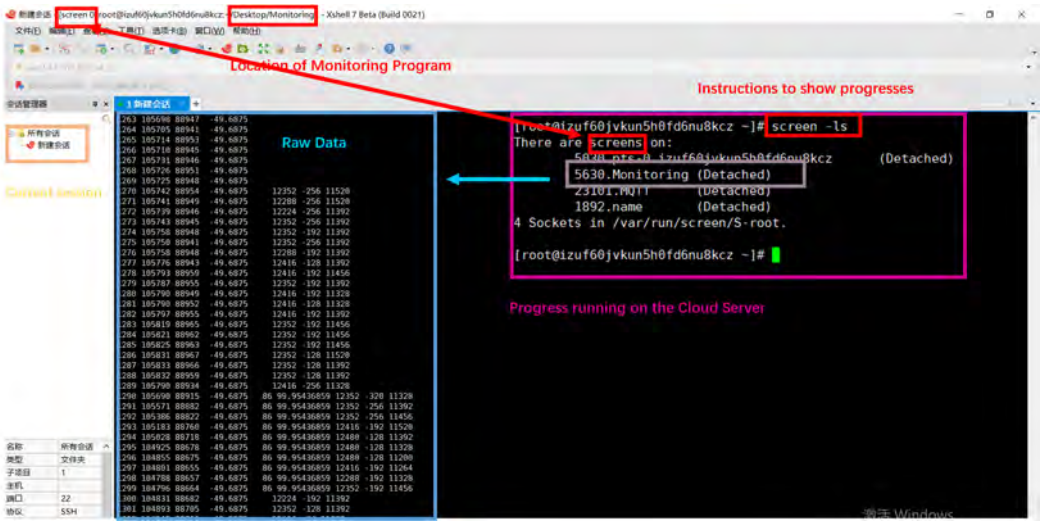


Figure 9: Raw Data

The measurement is still down on the index of finger. Note that the LEDs are very sensitive to the environment light, thus a black fingertip is very necessary to get results with high accuracy. Besides, a WEMOS development board is applied to access the internet through WIFI module and details will be shown in section 3.3 (Internet of Things).

3.1.4 Pre-processing

Before implement algorithm to calculate health index, preprocessing of the original signal is necessary. The preprocessing procedure is shown as Figure 8.

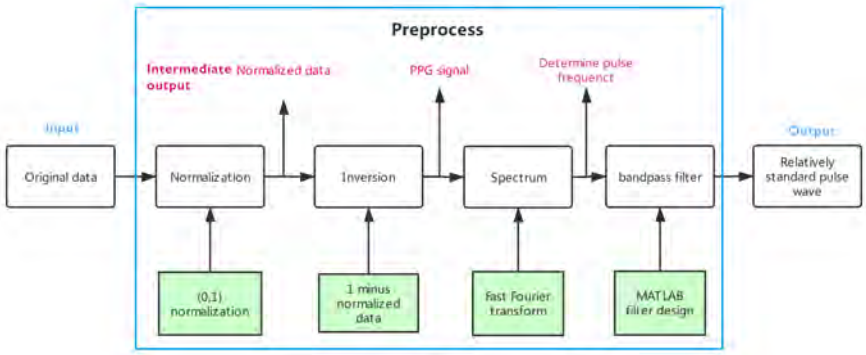
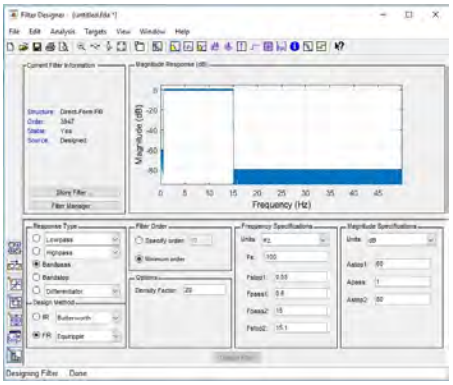


Figure 10: Preprocessing Flowchart

In the first place, (0,1) normalization is applied for improving data structure and it is implemented through the formula below.

$$\boldsymbol{data = \frac{data - minimum}{maximum - minimum}}$$

In the second place, the original data value is actually the reflected light intensity and is reversely proportionable to blood volume. Thus, to obtain the correct pulse wave, the inversion of original PPG graph is necessary. The inversion is implemented through using 1 minus all normalized data. Then After introducing spectrum using MATLAB, there is a frequency component with high power appears at 0Hz and there are some frequency components appears at high frequency domain. However, the frequency of pulse wave is supposed to be around 1 Hz. Therefore, a bandpass filter with 0.6Hz to 15 Hz passband (shown as Figure 8) is introduced to eliminate dc component, respiratory disturbance and high frequency component [20].



	Parameters	Value
Frequency Specifications	Unit	Hz
	Fs	100
	Fstop1	0.55
	Fpass1	0.6
	Fpass2	15
	Fstop2	15.1
Magnitude Specifications	Unit	dB
	Astop1	60
	Apass	1
	Astop2	80

Figure 11: Bandpass Filter Implementation

3.1.5 Single Period Division

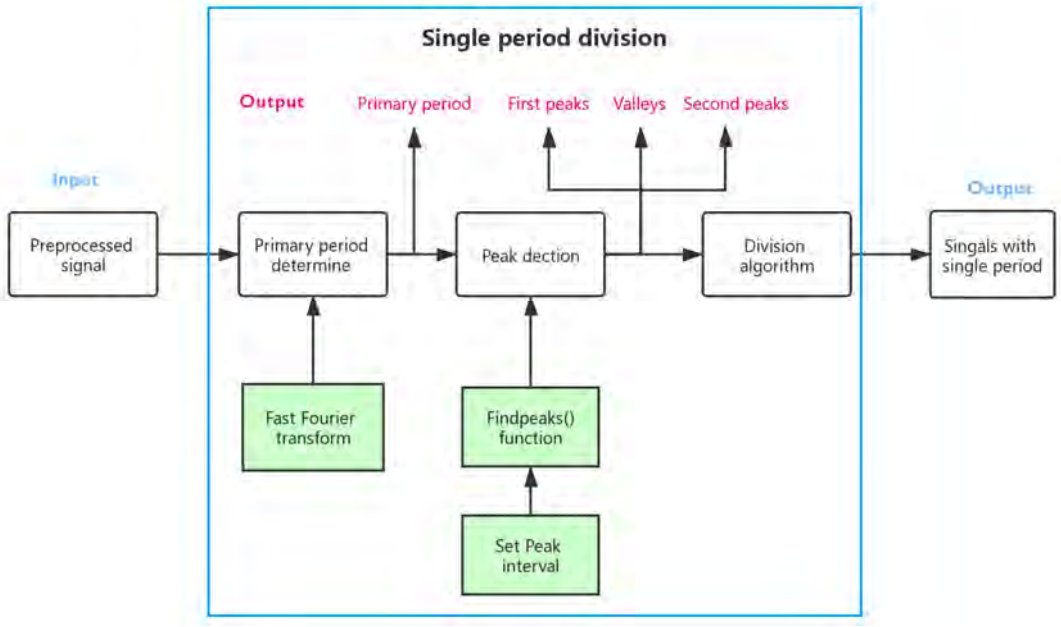


Figure 12: Flow Chart for Single Period Division

Firstly, fast Fourier transform and findpeaks() function are applied to find the heart rate frequency which is supposed to at about 1 Hz. Then the frequency is transformed to period according to the relationship that $\boldsymbol{Primary\ period} = \boldsymbol{Sample\ rate} * \frac{\mathbf{1}}{\boldsymbol{frequency}}$. After obtaining the primary period, the search interval of findpeaks() function is set to $primary\ period - 20$ and then the values and locations of all first peaks can be acquired. To acquire valleys, signal inversion is implemented at first. Then through repeating the method that find first peaks, the values and locations of all valleys can be obtained. Note that the locations and values for both the first peaks and valleys are stored in two different arrays. Finally, by setting the search interval to minimum and calling findpeaks() function again, the values and locations of both the second peaks and the first peaks will be stored in two new array. The data architecture for now is shown below.

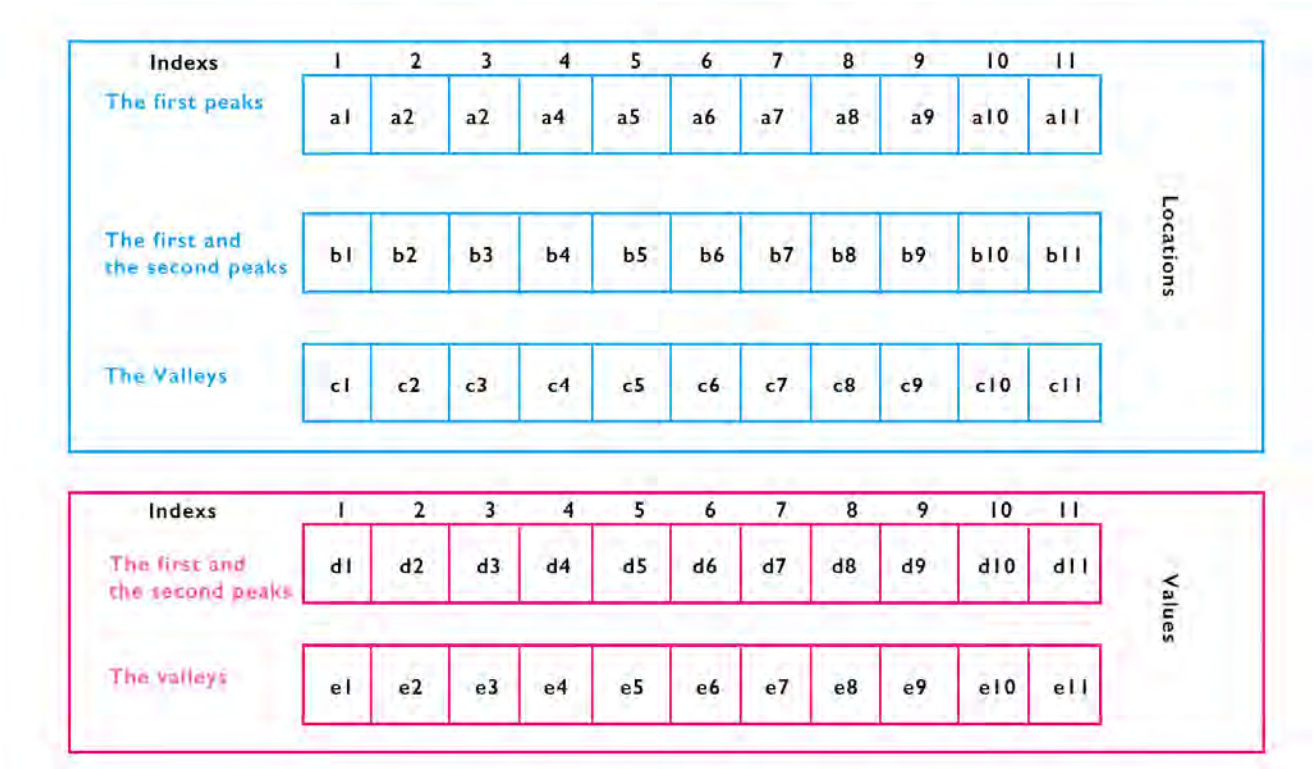


Figure 13: Data Architecture

The single period division algorithm is implemented on the basis of the data architecture shown in Figure 11 and the pseudocode diagram is shown below.

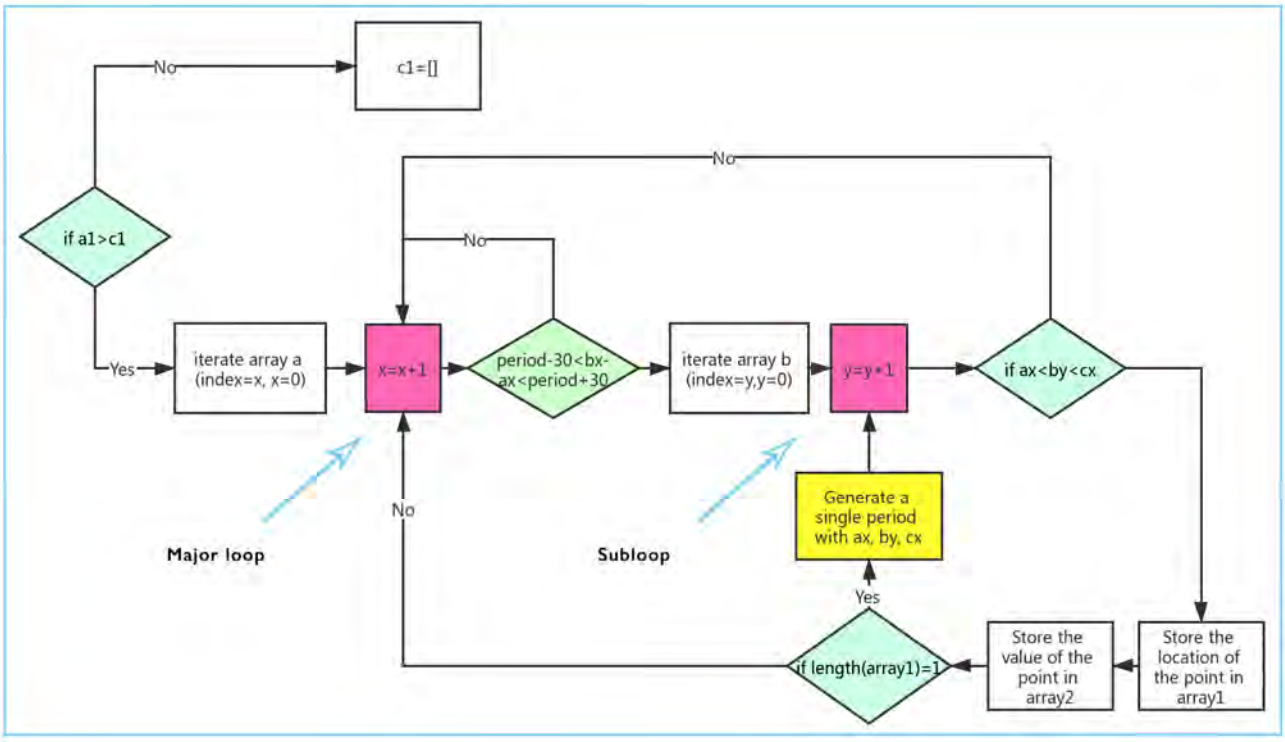
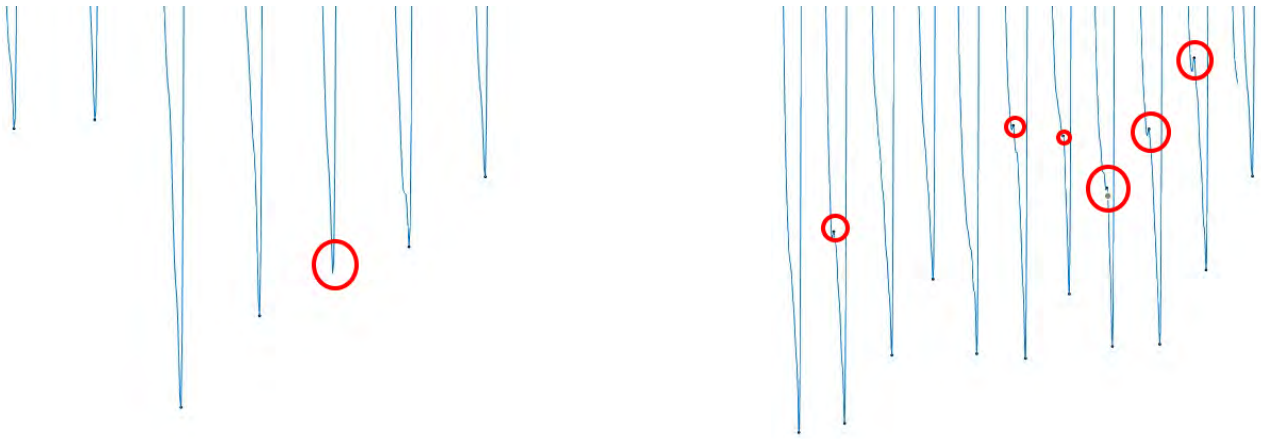


Figure 14: Pseudocode Diagram

There are few important scenarios in Figure 11, which are list below.

1. **bx-ax>period (primary period) +30.** One situation is the first peak and the valley not belong to the same single period, which may cause by condition that there missed a peak during peak detection procedure (the distance of adjacent peaks is larger than search interval). Another situation is the distance between this first peak and valley is too large. For result accuracy, this single period is ignored.
2. **bx-ax<period (primary period)-30.** One situation is the distance of between this first peak and valley is too small. Another situation is there is a wrong detected peak or valley cause by noise. For result accuracy, this single period is ignored.
3. **a1<c1.** a1<c1 means valley appear firstly for the selected signal section, thus the first valley is removed. Then for a specific index shown in Figure 10, the value stored in array a always smaller than the value stored in array c.
4. **Length (array1)>1.** Length(array1)>1 means there are not only one local peak during a specific period, which may cause by noise signal. Thus, for guaranteeing result accuracy, this single period is removed.

The majority of following algorithms are based on each single period signal, locations and values of first peaks, second peaks and valleys.



(a). Scenario 1 **(b). Scenario 4**

Figure 15: Abnormal Scenario Demonstration

3.1.6 Arterial Vessel Assessment

Three indexes were established to evaluate vascular compliance that crease time SI and RI, both of them are proved have close relationship with arteriosclerosis [17].

$$RI = \frac{b}{a} \times 100\%$$

Where, b is the value of second peak during one period of pulse wave and a is the peak value of the same peak value. High RI usually represents relatively high artery stiffness. RI is increased due to the decrease of peak value and the increase of the second peak value. To be more specific, during arteriosclerosis process, the resistance will increase and the capacity will decrease which will lead to the decrease of peak value.

$$\mathrm{SI} = \frac{\mathrm{H}}{\Delta \mathrm{T}}$$

$\Delta \mathrm{T}$ is the pulse propagation time shown in Figure 2 (b), and H is the height of testee. Stiffness index (SI) is a measure of relatively large artery stiffness. The arteriosclerosis procedure will lead to low artery compliance and the decent of ΔT.

Crest time is defined as the time from the beginning of the period to the peak of the same period (as shown in Figure 2 (b)). The increase of vascular blood flow resistance will lead to the increase of crest time and crest time has been proven to be a useful index for classification of cardiovascular disease [5].

The calculation of RI and SI is on the basis of each single period signals. Cause the peak, second peak and valley of each single period signal is obtained, the value of SI and RI can be calculated. Crest time is calculated from the distance of adjacent valley and first peak. Besides, crest time, RI and SI is calculated for each single period and abnormal values are moved out. The abnormal value is identified by the formula shown below.

$$outlier \begin{cases} value > mean + 2 \times standard\ deviation \\ value < mean - 2 \times standard\ deviation \end{cases}$$

3.1.7 Cardiac Evaluation Algorithms

1. Heart Rate calculation

Both instantaneous heart rate and average heart rate are implemented. For instantaneous, the distance of adjacent first peaks are calculated and is transformed to corresponding time according to sample frequency. Then instantaneous heart rate is calculated through dividing 60 by the calculated time.

$$heart\ rate_{instantaneous} = \frac{peak\ index_{next} - peak\ index_{pre}}{sample\ rate} \times \frac{1}{60}$$

Average heart rate is implemented through the formula blow.

$$heart\ rate_{average} = \frac{Primary\ period}{sample\ rate} \times \frac{1}{60}$$

Note that Primary period is calculated during single period division process.

2. Heart rate variability calculation

Note that only the time domain analysis of HRV was implemented in this semester, the frequency analysis may implement in next semester. The time domain analysis of HRV is one the basis of two index that SDNN (standard deviation of NN intervals) and RMSSD (root mean square of successive difference). To obtain the value of SDNN, firstly the locations of all first peaks (obtained from single period division process) are applied for intervals calculation and the results are stored in a array. Then the standard deviation of intervals is calculated by introducing std () function provided by MATLAB. On the basis of SDNN calculation, a new array is applied for storing the difference between two adjacent intervals. Then RMSSD can be acquired by applying std () function to the new array. **Note that to obtain meaningful SDNN and RMSSD, a continuous (5-minute window based) measurement will be more preferred as it will reveal the trends. However, the measured data for this report is just 90 seconds. Therefore, the results of SDNN and RMSSD will not be shown in health report for now.**

3.1.8 Spo2 Algorithm

The calculation of Spo2 is quite complicated, in a general sense Spo2 is calculated from the equation below.

$$Spo2 = \frac{C_{Hbo_2}}{C_{Hbo_2} + C_{Hb}} \times 100\%$$

The speculation of Spo2 is on the basis of an assumption that oxygenated hemoglobin and deoxygenated hemoglobin are the only two components that cause the change of transmitted beam intensity. Besides, Beer-Lambert law is applied to calculate Spo2.

Beer-Lambert law is shown below:

$$I = I_0 e^{-\varepsilon CD}$$

I_0 represents incident light intensity, I is transmitted light intensity, C and D represent the solution concentration and thickness respectively, ε is absorption coefficient. When artery is at stable state:

$$I_{DC} = I_0 e^{-\varepsilon_0 C_0 D} e^{-\varepsilon_{Hbo2} C_{Hbo2} D} e^{-\varepsilon_{Hb} C_{Hb} D}$$

$e^{-\varepsilon_0 C_0 D}$ represents the change caused by tissues with constant absorption rate.

Under the condition of arteriopalmus, the variation of optical path is assumed to be ΔL, and on the basis of calculation of I_{DC}, the formula shown below can be inferred.

$$\frac{I_{AC}}{I_{DC}} = -(\varepsilon_{Hbo2} C_{Hbo2} + -\varepsilon_{Hb} C_{Hb}) \Delta L$$

Cause ΔL is unknown, thus the processed data acquired from both LEDs are needed to estimate ΔL.

$$x_1 = \frac{I_{AC}^{\lambda 1}}{I_{DC}^{\lambda 1}} \qquad x_2 = \frac{I_{AC}^{\lambda 2}}{I_{DC}^{\lambda 2}}$$

$$R = \frac{x_1}{x_2} = \frac{\varepsilon_{Hbo2}^{\lambda 1} C_{Hbo2} + \varepsilon_{Hb}^{\lambda 1} C_{Hb}}{\varepsilon_{Hbo2}^{\lambda 2} C_{Hbo2} + \varepsilon_{Hb}^{\lambda 2} C_{Hb}}$$

According to S. Prahl [21], the value of R in range 0.3 to 0.4 can be turned to the approximate value of Spo2 according to the formula given below:

$$SpO2 = 104 - 17R$$

The AC component and the DC component of PPG signal need to be determined, to calculate R. DC component value is obtained by using two adjacent minimum values determine the approximated straight line. AC component value is the vertical distance between the peak to the approximated straight line.

3.2 Website Development

3.2.1 Outline

3.2.1.1 Design Architecture

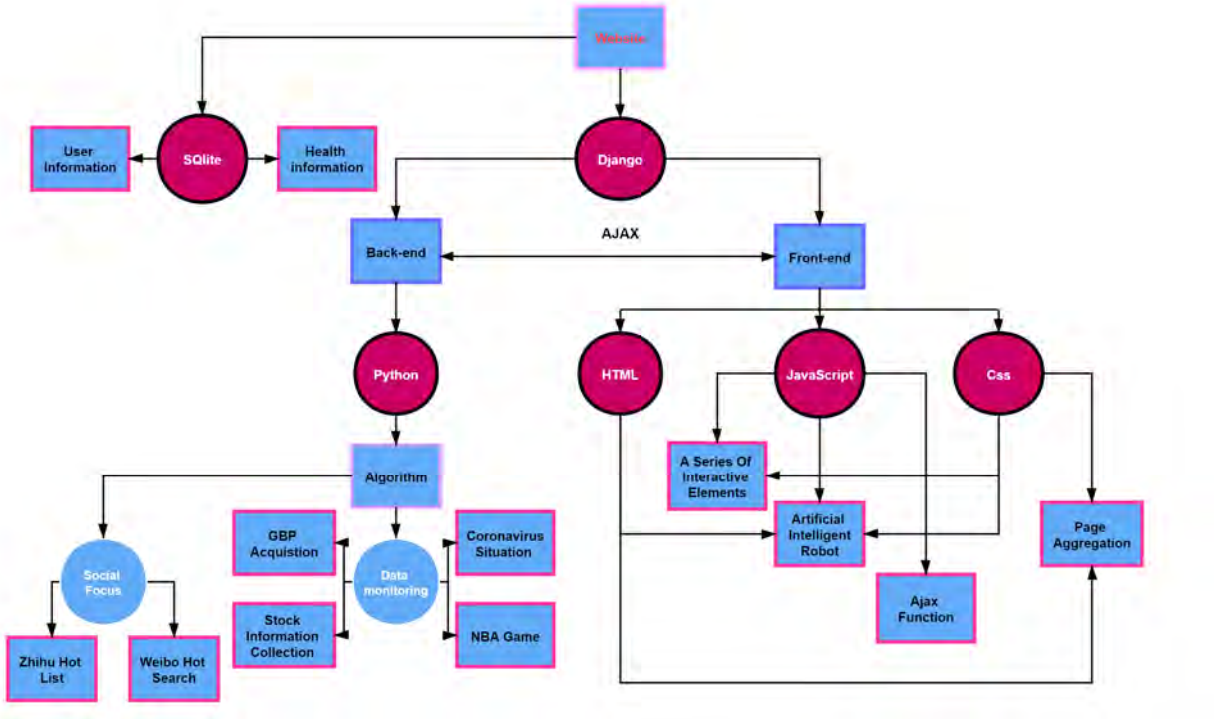


Figure 16: Website Design Architecture

Components	Description
Django 3.0.1	The Framework applied to develop the web
SQLite 3.0	The Database chosen to store the records
Back-end	In charge of functional module, database interaction and logic process
Front-end	In charge of the exterior design, visual effects
Ajax	In charge of the communication between back-end and front-end

Table 2: Website Components and Descriptions

Languages	Purposes
Python 3.8.2	Implement Django framework, web clawer, and functional modules
Html	Implement the details of each page such as texts, pictures and videos
JavaScript	Implement dynamic function, Ajax function and functional modules
Css	Implement the layout of each page and the decorate each page

Table 3: Applied Languages

3.2.1.2 Website Architecture

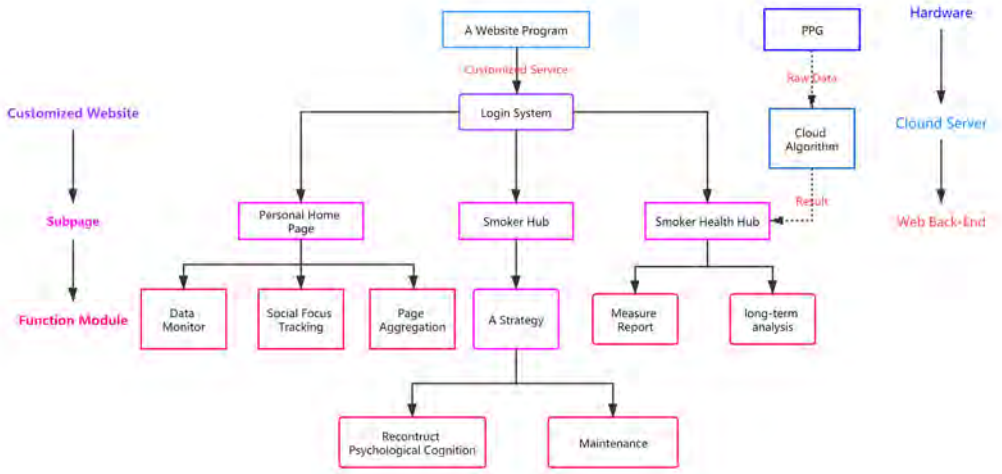


Figure 17 : Website Architecture

(1). Personal Home Page

Personal home page is designed to improve user experience by providing user with a series of information that they may interested in, in real-time. Besides, personal home page may increase the time that smokers spend on this website, so that they can get the support they need on time. Additionally, compared with other websites, this page can let the website become more competitive.

(2). Psychological Therapy

Smoker hub page realized a psychological therapy. The whole therapy has been divided into four steps:

Figure 18: Psychological Therapy

All of these four steps are implemented by a series of interactive and creative elements. Details will be given in 3.2.3.2 Front-end section.

(3). Health Analysis Page

This page is developed to display the health analysis result and display the PPG signal in real time through Internet of Things technique.

3.2.1.3 Functional Module Architecture

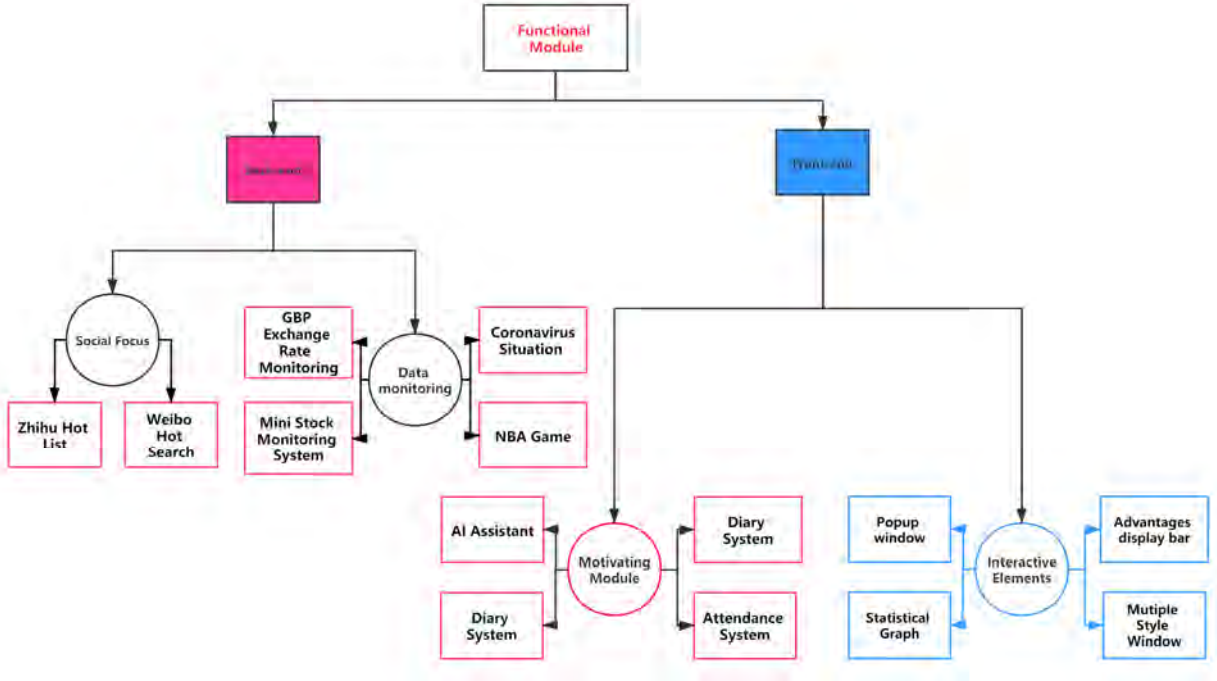


Figure 19: Functional Module Architecture

Functional Module	Description
GBP Exchange Rate Monitoring	This module is designed to monitor the change of GBP rate and return the latest information
Mini Stock Monitoring System	This module allows user monitor a specific stock by inputting the corresponding stock code
2019-nCoV	This module allows user monitor the current 2019-nCoV situation
NBA Game System	This module allows user catch up the latest game information
Social Hot Issues Tracking module	This module allows user tracking the social affairs, the affairs are climbed down from Zhihu and Weibo, which are two famous social interaction platform
AI Assistant	This module allows user chat with AI assistant and consult assistant for advices
Diary System	Diary system is designed to provide user a way to record their feelings and these diaries may become to a part of the motivation of user to quit the habit
Attendance System	This module is designed to visualize the accomplishment of smoker which may become to a part of motivation of user further

Table 4: Functional Modules and Descriptions

Interactive Elements	Description
Popup Window	This window allows video or picture to be played or displayed in the page
Advantages Display Bar	This advantage display bar shows the potential advantages of smoking cessation with good visual effect
Statistical Graph	Show user with a series of data with good visual effect
Multiple Style Window	Use three different exterior design help smokers realize the reasons that they keep smoking are not rational

Table 5:Interactive Elements and Descriptions

3.2.2 Django Framework Implement

In this project Django framework is adopted to develop the website.

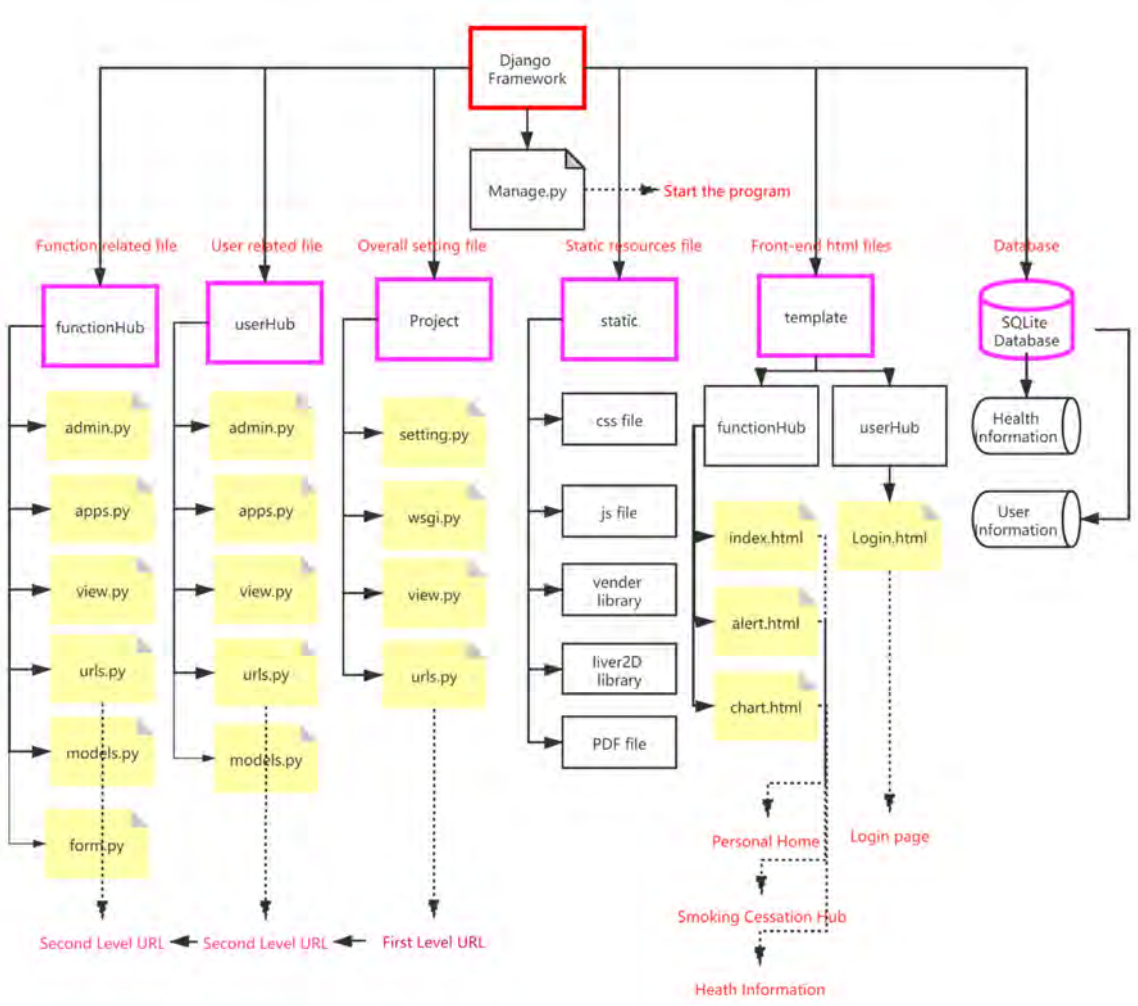


Figure 20: Django File Architecture

Modules	Description
manage.py	The starting position of the whole website
functionHub.admin.py	Control the health information stored in database
userHub.admin.py	Control the user information stored in database
functionHub.view.py	Render the template.functionHub and implement functional code
userHub.view.py	Render the template.userHub and implement login function
functionHub.models.py	Implement health record object
userHub.models.py	Implement user record object
Project.urls.py	Register the first level URL such as public net IP of cloud server
functionHub.urls.py	Register index.html, alert.html, chart.html to the route form
UserHub.urls.py	Register Login.html to the route form
static file	Store all the static resources included font file, pdf file, css file
template file	Store all the front-end html file

Table 6: The Important Components of Django Architecture

3.2.3 Back-end Implementation

The Back-end of the website consist of a series of functional modules and all the functional modules are implemented in functionHub.view.py, userHub.view.py Almost all the functional modules involve Ajax (Asynchronous JavaScript and XML) technique which is a powerful technique for interactive and dynamic website development. To be more specific, it can update information partially without refresh the whole page. To be more specific, asynchronous means when web ask information from an URL through Ajax, it excuse the next line of code directly without waiting for the result of the request and the web render the returned information when the result finally comes. The process procedure of Ajax is shown below:

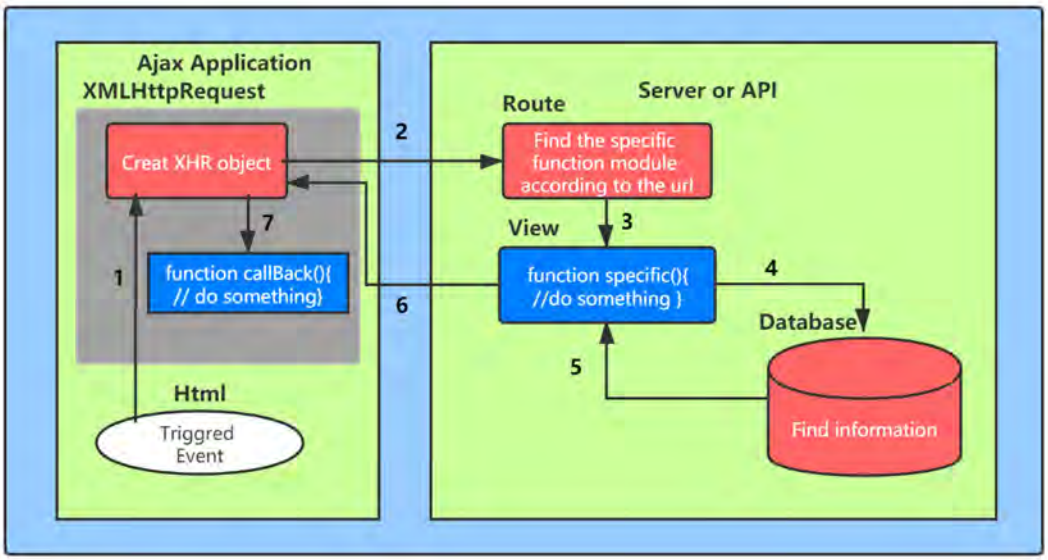


Figure 21: The Process Procedure of Ajax Technique

3.2.3.1 GBP (Great Britain Pound) Exchange Rate Tracking Module

This module is designed to acquire the latest GBP (can be changed to any currency) exchange rate through web crawler technique in the real time and display the information on the front-end through Ajax technique. The Front-end call the Ajax function for a specific time interval (The IP address may be banned from the requested web for the high request amount, if the access interval is too short), then the Ajax will access the assigned URL which is associated with a certain function in the route form. The corresponding function access the Bank of China official web and acquire all the html text, then return GBP rate after process the html text with beautiful soap library. When the Ajax function receive the GBP rate it updates the specific area to display the latest GBP rate. **Beautiful soap**

is a python library used to select the specific text area, which similar with regular expression and xpath (used in other function module).

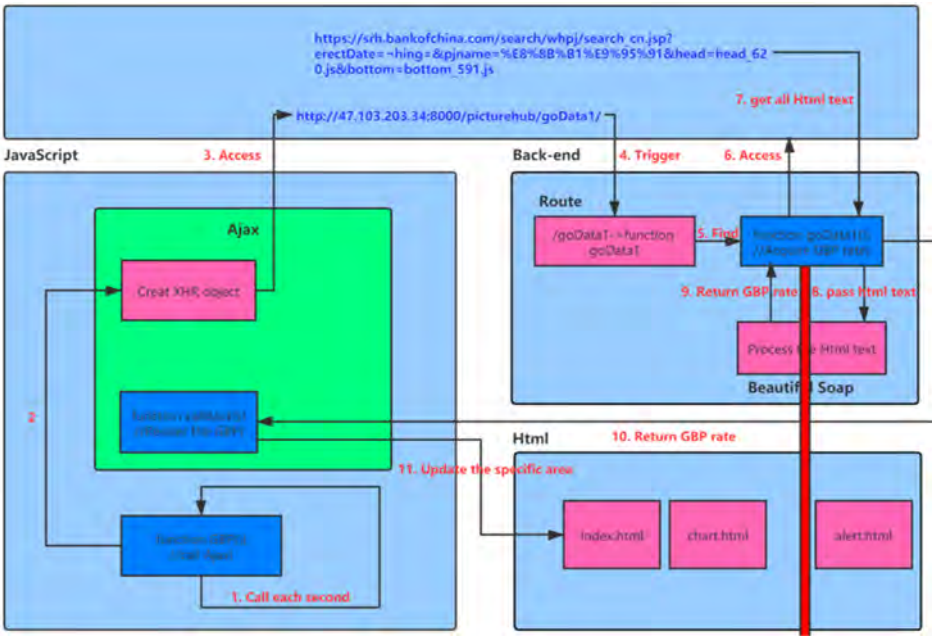


Figure 22: GBP Rate Tracking Flow

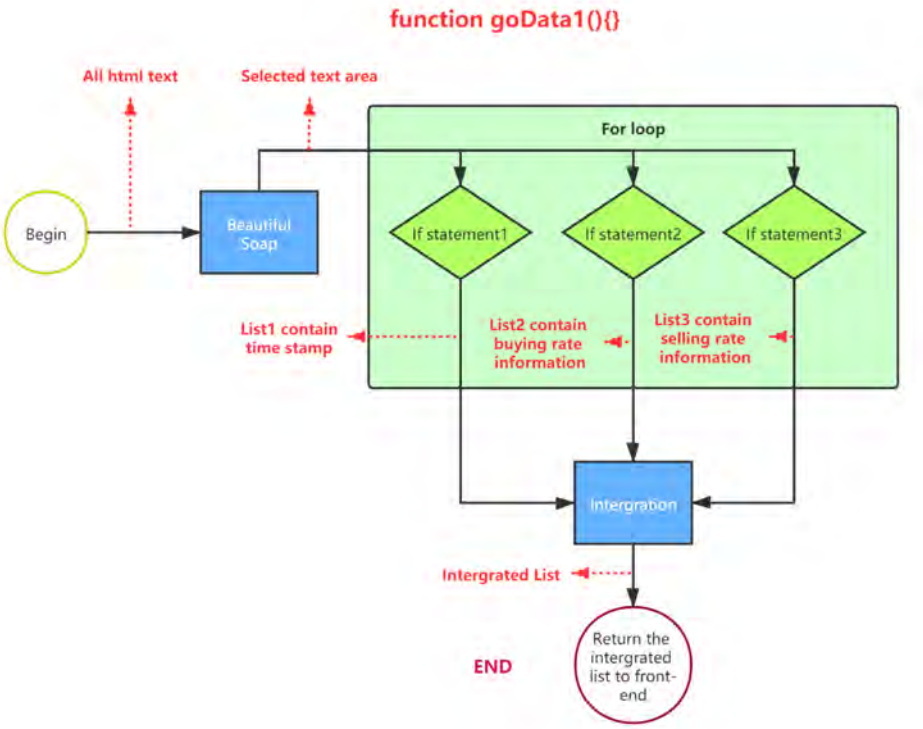


Figure 23: Diagram of Function goData1(){}

The Data is climbed down from Bank of China official web:

https://srh.bankofchina.com/search/whpj/search_cn.jsp?erectDate=&nothing=&pjname=%E8%8B%B1%E9%95%91&head=head_620.js&bottom=bottom_591.js

3.2.2.2 Stock Monitoring Module

This module is designed to implement a mini Stock Information platform, where user can monitor any stock and acquire its related information in real time. Firstly, User input a specific stock code on the front-end. Then the Ajax function post the code to a URL which is associated with a corresponding function (**goData**) in functionHub.view.py. Then the function calls the **tushare** API with the given stock code. After goData function receive related information from API, it sends the information the Ajax function. Finally, Ajax update targeted area to display the updated specific stock information.

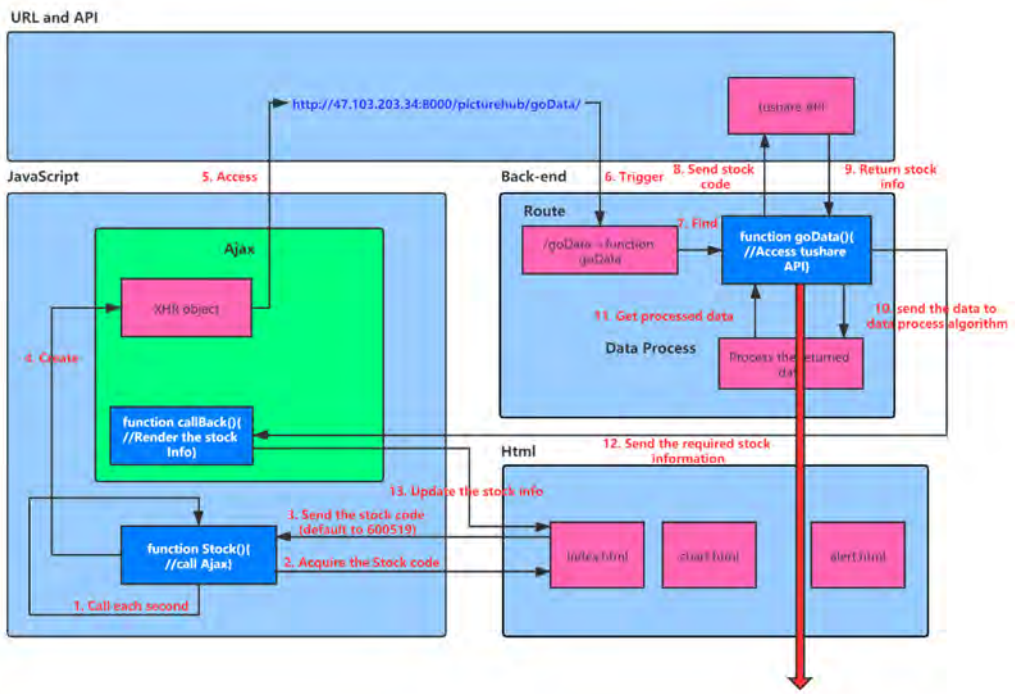


Figure 24: Stock Monitoring Flow

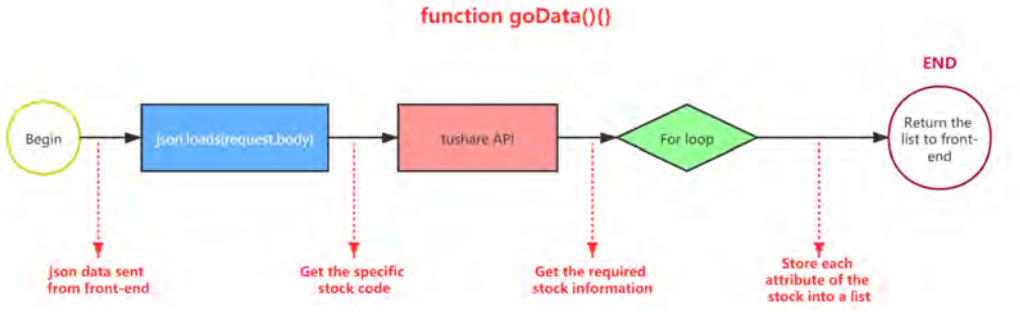


Figure 25: Diagram of Function goData(){}

Tushare is a financial data interface package which allow user acquire latest financial data.

Tushare GitHub address: https://github.com/waditu/Tushare

3.2.2.4 Coronavirus Monitoring Module

Coronavirus, which has brought severe challenge to the whole globe, is one of the significant components of people's concern. **This module is designed to let user grasp the latest coronavirus related information in real time. The whole procedures are similar with the GBP monitoring module (Referring to the Figure above), but the data process is more complicated:**

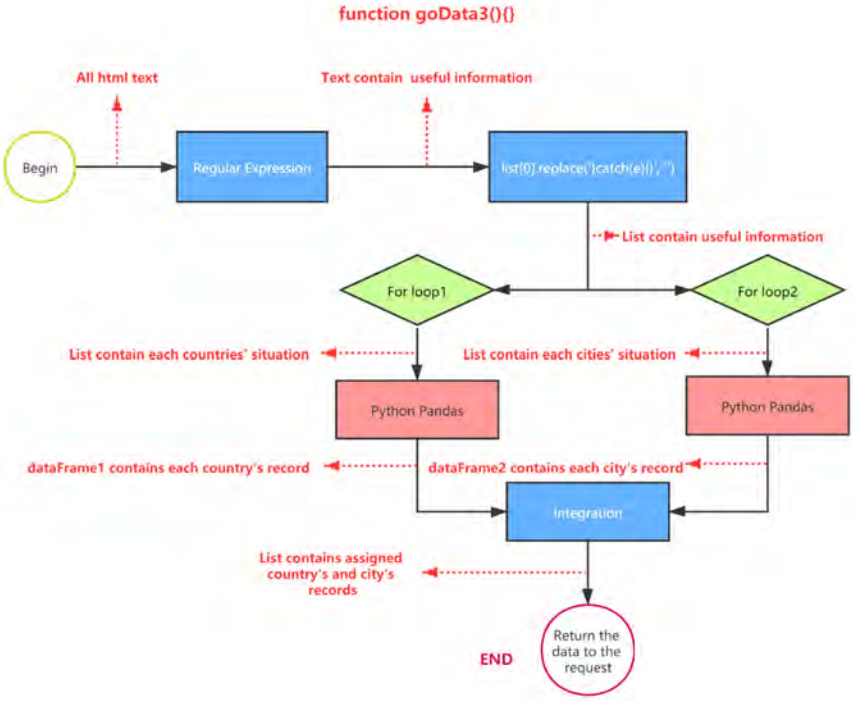


Figure 26: Algorithm for Coronavirus Monitoring

The core procedures are shown in the Figure above, the whole algorithm consist of 200 lines of code, the expression of each core procedures are listed below:

1. Regular Expression is introduced to get the specific text area with matching condition: 'window.getAreaStat = ([\s\S]*?)</script>'
2. list[0].replace('}catch(e){}', '') is applied to divide the text into a series of slices which is stored in a list further.
3. For loop1 is used to load each country's epidemic situation into a list (a data structure) and for loop2 is used to load each city's epidemic situation in to another list.
4. Python pandas is a python library used for data process and it is applied for collect and trim the data stored in lists.
5. Integration is used to combine two dataFrame together and transform it into a list, which is the ultimate form that returned to front-end.

The Data is climbed down from DXY Ding Xiang Yuan):

https://ncov.dxy.cn/ncovh5/view/pneumonia?from=timeline

3.2.2.4 National Basketball Association Game Monitoring Module

Sports competition is always a hot topic, this module provides a simple way which allow users catch on the game process in real time. Note that this module can not only applied to monitor NBA competition process but also **can track other kinds of sport competition** by making some little modifications. The function goData4(){} not contain many technical skills, thus the details of goData4(){} is not provided here. However, the procedures of getting the original URL that contain NBA game competition information, are shown below:

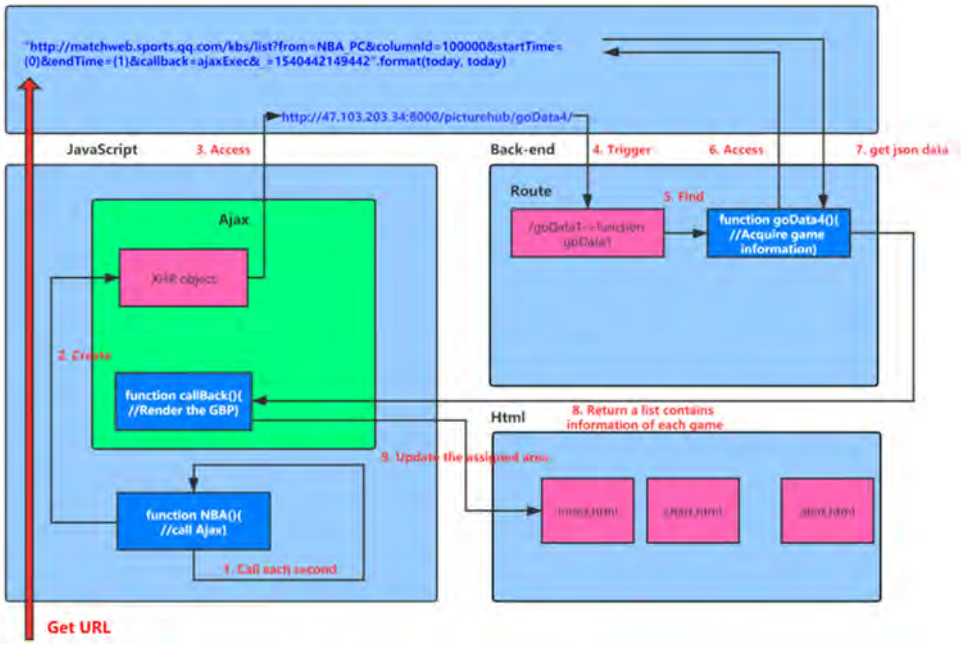


Figure 27: NBA Game Tracking Flow

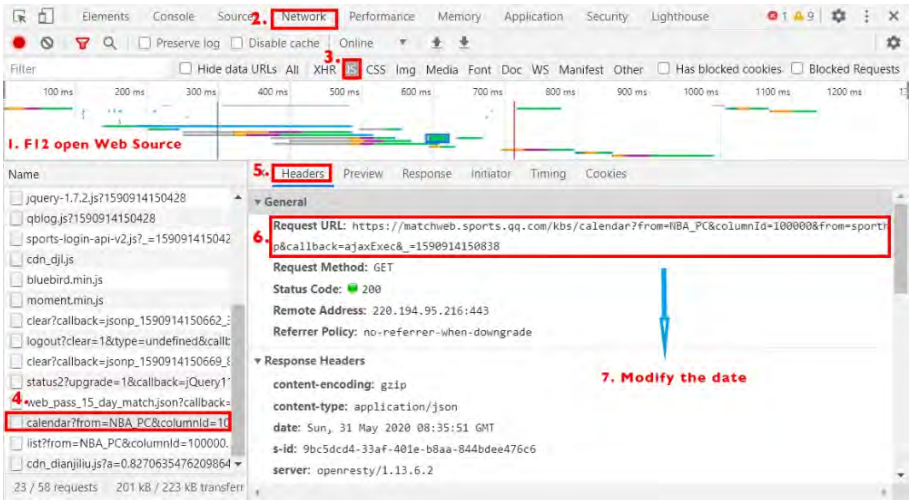


Figure 28: Simplified Demonstration of Getting Game Data URL

Note that the starting URL is Tencent NBA: http://nba.stats.qq.com/schedule/. Network shows all internet request information. JS shows the all .js resources which contain original data. Header includes all the related information about the resource such as request URL, http method, response status code, request parameter and so on.

3.2.2.5 Social Focus Tracking

Social Focus Tracking module is designed to present real-time social hot topic to user. The data is climbed down from two official webs that Weibo and Zhihu:

https://s.weibo.com/top/summary?Refer=top_hot&topnav=1&wvr=6

https://www.zhihu.com/hot

The whole Tracking flow is similar with the modules' shown above, the triggered event is not a specific time interval, but a clicking event (the ajax function will begin when user click the refresh button shown in the front-end)

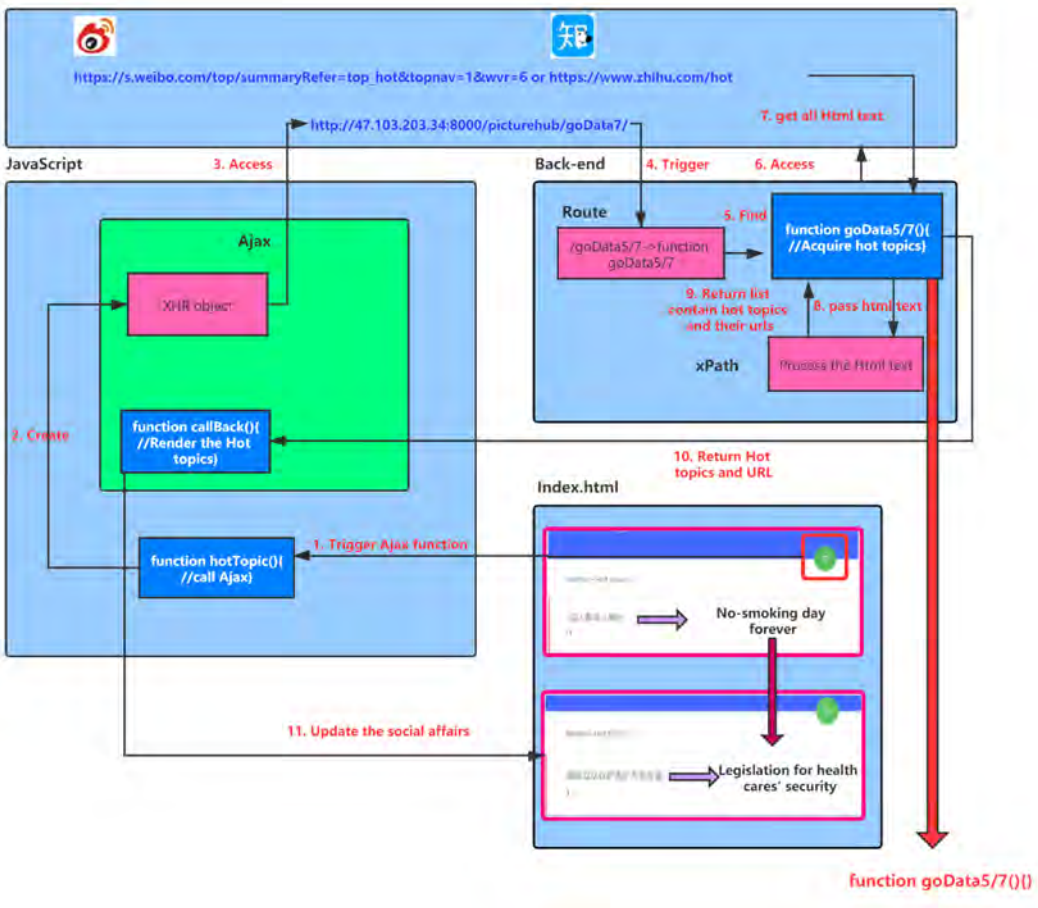


Figure 29: Social Hot Topics Tracking Flow

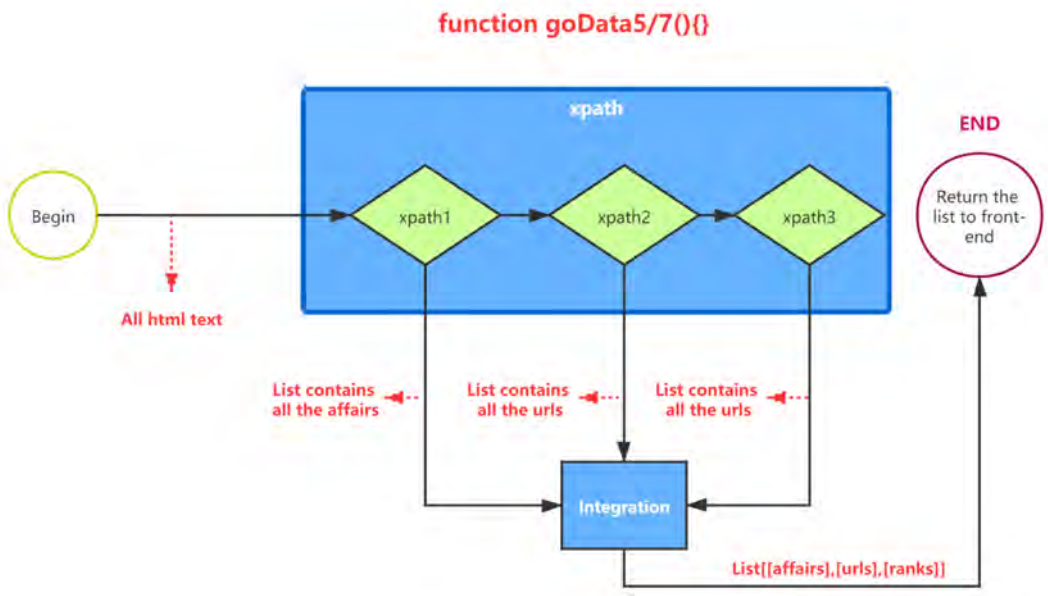


Figure 30: Function goData5/7 Diagram

Different with regular expression and beautiful soap mentioned above, XPath is not a python library, but an XML Path Language which is designed for finding a specific location of an XML file.

XPath1: '//td[@class="td-02"]/a/text()' – matching the affairs in the html text

XPath2: '//td[@class="td-02"]/a/@href' – matching the URLs in the html text

XPath1: '//td[@class="td-01 ranktop"]/text()'– matching the ranks in the html text

3.2.4 Front-end Implementation

The front-end is developed on the basis of the Bootstrap framework. Bootstrap frame work, based on CSS, Html, JavaScript and developed in dynamic CSS language Less, provides programmer with a basic structure with grid system, link style and background.

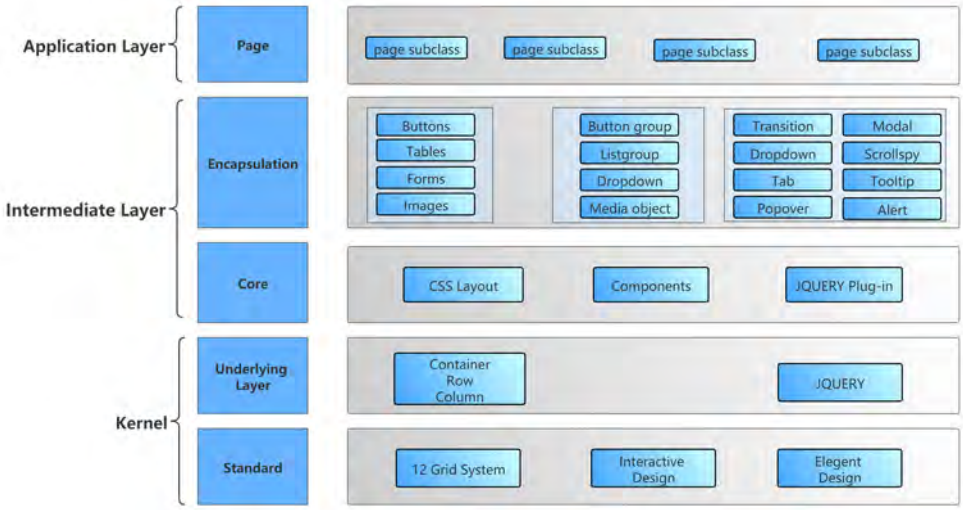


Figure 31: Bootstrap Framework

On the basis of the bootstrap framework, a series of elements are developed according the process shown below:

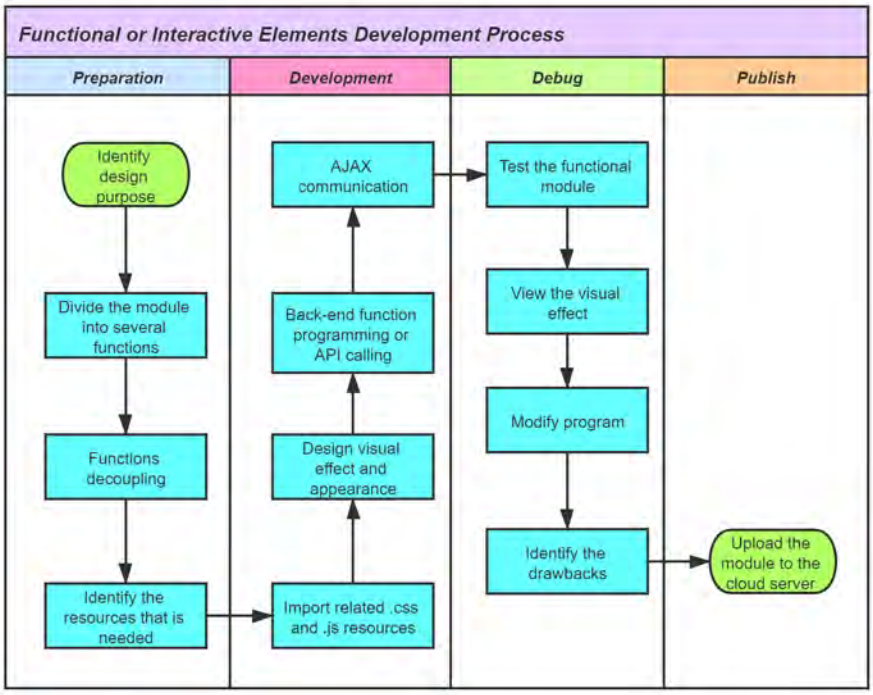


Figure 32: Elements Development Process

The whole front-end involves lots of coding work, the main elements are shown below:

3.2.4.1 Personal intelligent Assistant

This module intends to develop an intelligent assistant, who can chat with users and provide them with many useful guidance or advices. The appearance design is on the basis of the Live2D project and the chat function is implemented by introducing Turing API. Live2D is an open source project on GitHub, and Turing API is developed by Turing Robot company, but no one ever combined them together before.

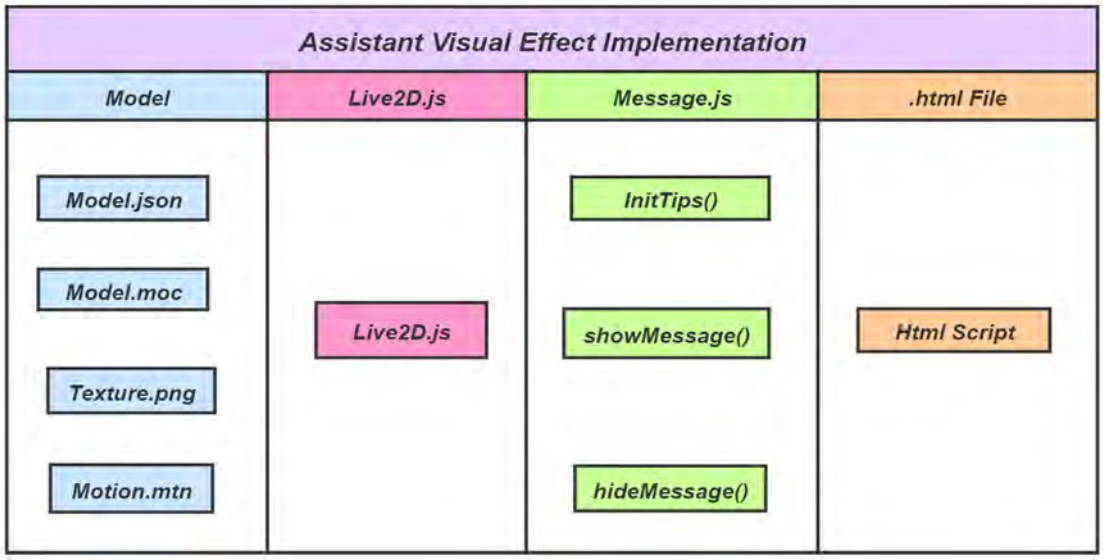


Figure 33: Live2D Implementation Diagram

Components	Subcomponents	Description
Model	Texture.png	Picture materials
	Motion.mtn	Define each motion through a set of points' locations.
	Model.json	Data Collection of motions and textures
	Model.moc	Transform the motions defined in Motion.mtn into a signal
Message.js	InitTips()	Initialize the message box
	ShowMessage()	Show specific message in the message box
	HideMessage()	Hide the texts shown in the message box
Live2d.js	Provide related resources and dynamic functions	
HTML Script	Integrating components by calling them in a certain sequence	

Table 7: Assistant Exterior Design Components Description

This module has three independent functions according to three specific operations of users:

Case1: If user does not click the assistant or the answer button, assistant keeps telling users some disadvantages of smoking.

Case2: If user clicks the assistant, assistant tells user some advices about relieving smoking desire.

Case3: If user input some sentences and click the answer button, assistant gives specific responses due to the inputs.

Both Case 1 and Case 2 involve the communication between back-end and front-end. However, compared with the work done in front-end, the related functions written in back-end are relatively simple.

Case 1:

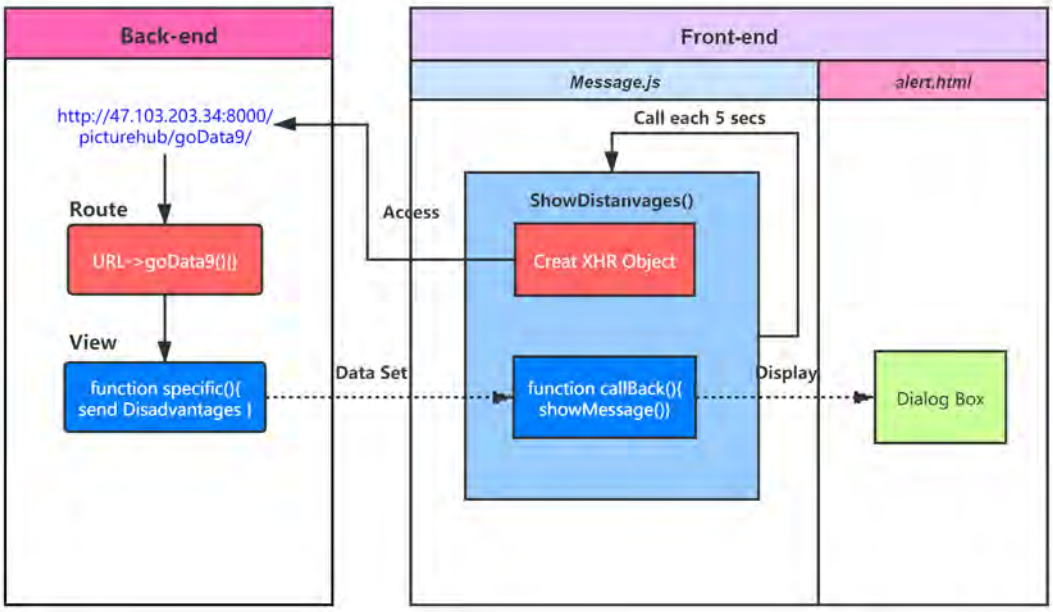


Figure 34: Intelligent Assistant Function Diagram (Case 1)

Case 2:

The only difference between the implementations of case 1 and case 2 is that two functions access two different URL, to get data resources, for function decoupling.

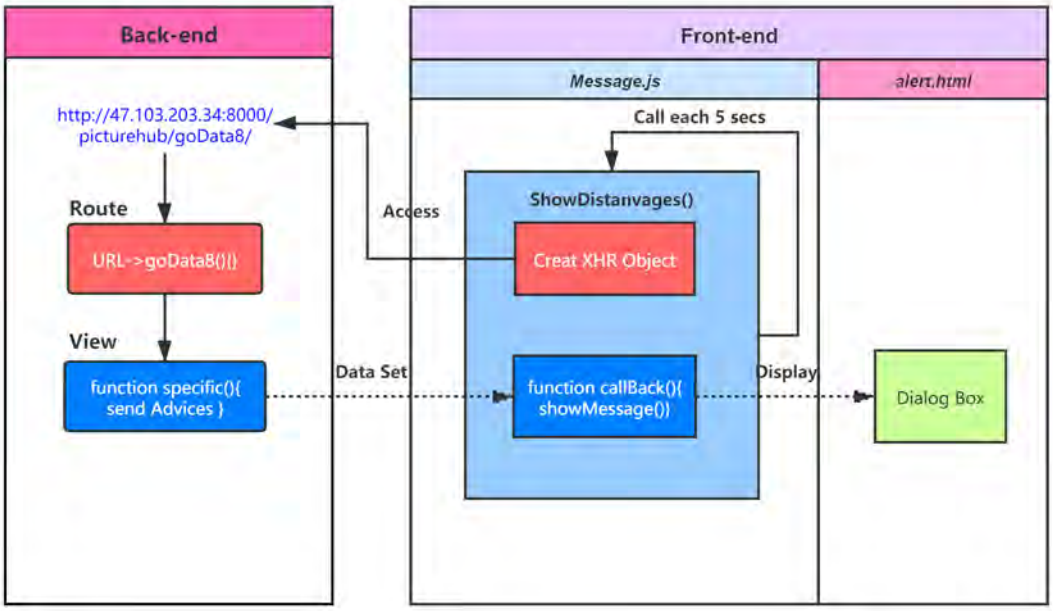


Figure 35: Intelligent Assistant Function Diagram (Case 2)

Case 3:

Case 3 is implemented on the basis of Turing API, by apply it, the assistant can respond the users' input.

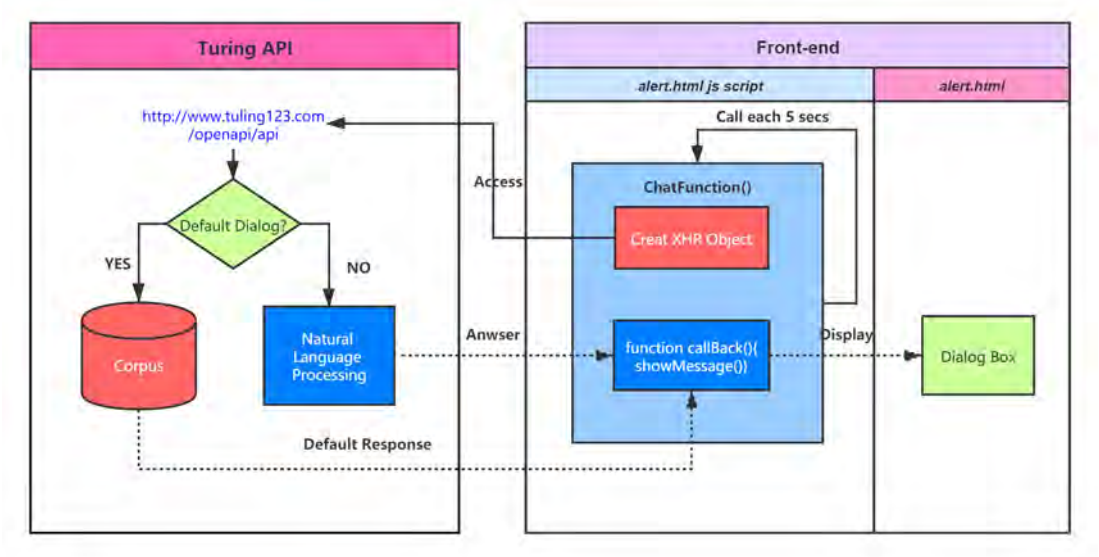


Figure 36: Intelligent Assistant Function Diagram (Case 3)

The Turing API allows user set personal corpuses. When a sentence is inputted, the Turing API will check if there is a corresponding preset dialog at first. If there is the Turing API will give the preset answer in response. Otherwise, a corresponding output will be given by applying the NLP (Natural Language Processing) technique. Note that, the training data of the neural network are all in Chinese. Thus if any input is given in English, the Assistant can only call the corpus to find a preset answer. The official website of Turing API is: http://www.turingapi.com/

	status	Problem (characters less than 64)	answer	Change the time
☐	Active	what's your name?	I am your assistant! Can't you recognize me?	2020-06-02 18:15:58
☐	Active	Do you want to chat with me?	Of course, how is your day so far?	2020-06-02 18:15:16
☐	Active	Quit smoking withdrawal response	1. Unusual sleep pattern 2. breathing rapidly 3. Bl...	2020-04-01 11:01:35
☐	Active	What is withdrawal response	Abstinence reaction (abstinence reaction) refers t...	2020-04-01 10:53:11
☐	Active	How to give up smoking	I have listed some advices above	2020-03-29 13:33:07
☐	Active	I want to smoke	Just soldier on, you are not a baby	2020-06-03 13:17:08
☐	Active	Can you speak English?	I'd like to give it a shot, but I am not very much in ...	2020-03-29 13:30:43
☐	Active	How are you	Hey, I am fine, just another normal day	2020-03-29 13:28:03
☐	Active	I want to smoke	No way! Hold on, Miss Ben chats with you at the ...	2020-03-29 13:19:42

Figure 37: Private Corpus of Turing API

3.4.2.2. Diary System

This module allows users to write electronic diary, which may become to a part of the motivation for smokers to stick to the smoking cessation progress. (This module currently is not perfect)

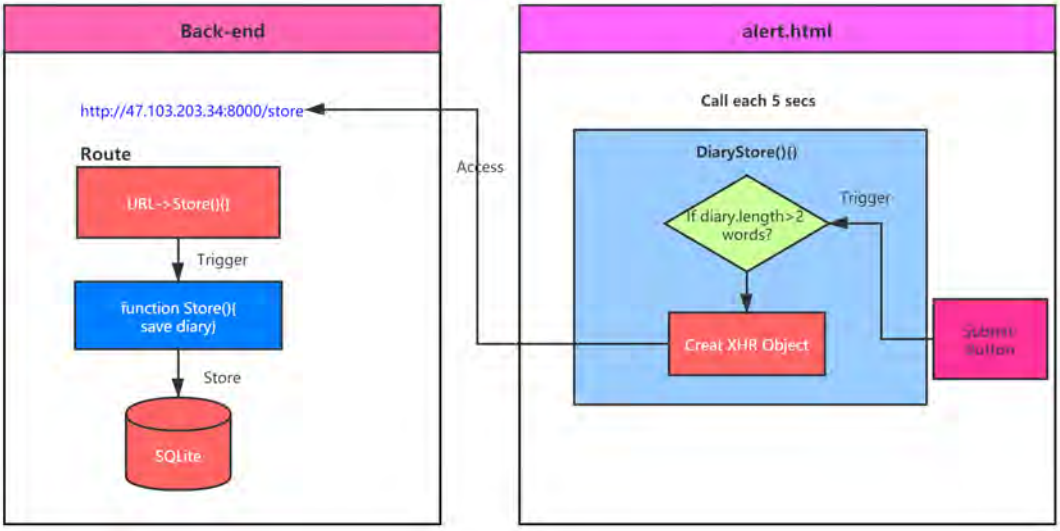


Figure 38: Diary System Design Diagram

When user access the smoking cessation Hub page, the back-end will automatically render the dairy system module with the diaries stored in the database.

3.4.2.3 Attendance System

This module is designed to record user's smoking cessation progress and allow user write a short summary for each day's performance or feeling.

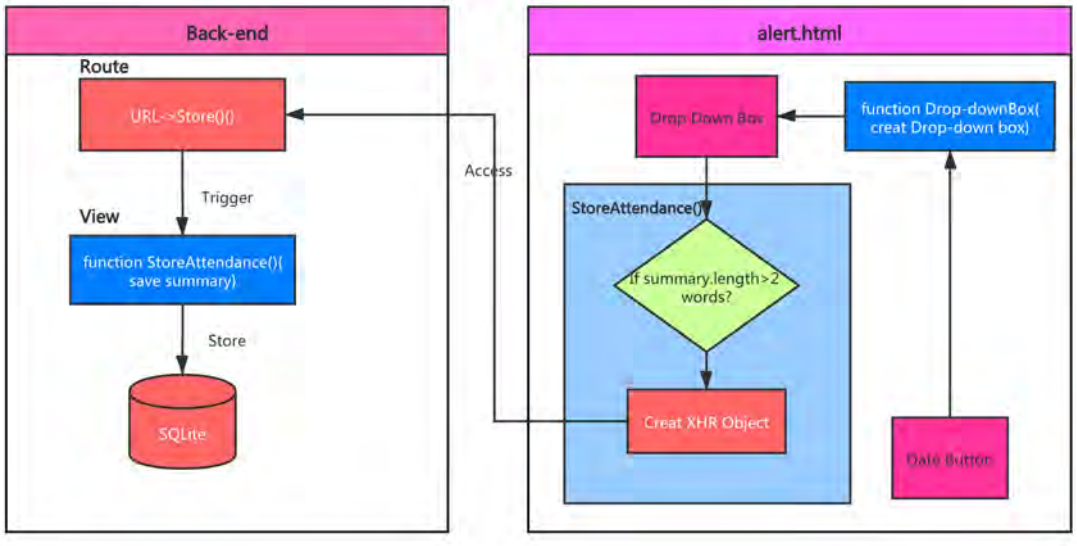


Figure 39: Attendance System Design Diagram

When User clicks date button on the calendar, a drop-down box will be shown under the date and user can fill it with a summary of the smoking cessation progress or feeling. When user click the other places, the drop-down box will be discarded and the corresponding summary will be transferred to the back-end and be stored in the database further.

3.4.2.4. Celebrities Stories Module

This module provides user with some smoking cessation reasons of the celebrities who have quit the habit. By clicking the celebrities' profile photo, user can access the smoking cessation stories of these celebrities.

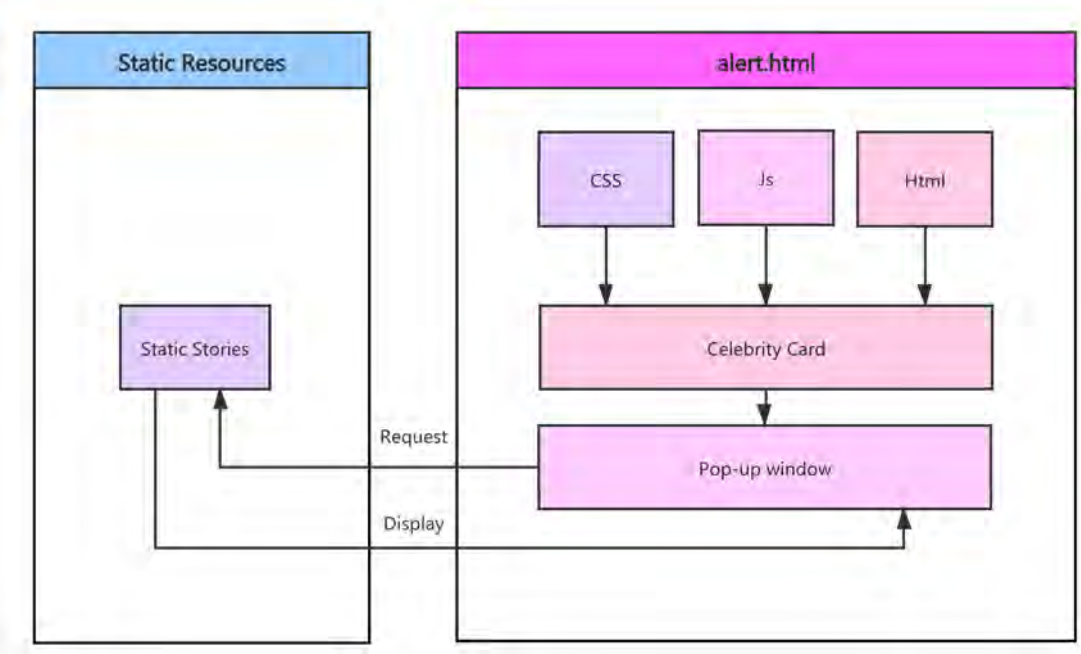


Figure 40: Celebrities Stories Module Diagram

3.4.2.5 Statistical Graph

This module is designed to show user a series of statistical data with good visual effect, to help them realize their situation better. This module is developed on the basis of morris.js, chartlist.js and canvas libraries. Html script is applied to decide the location of the graph and import other resources. CSS is introduced to set the style. JavaScript is used to fill data and implement dynamic effect.

3.2.5 Website Deployment

Cloud server is an essential component to allow users access the website. To be more specific, the whole Django Framework running on the cloud server. Therefore, the first step is to setup the cloud server. Note that, this part involve lots of coding work is hard to involve them all in this report, the details are shown in my blog : Website Deployment (**The whole blog can be translated into English with Google browser plug-in**)

3.2.5.1 Cloud Server Setup

(1). Cloud server purchase

The lightweight server of AliCloud is chosen for its relatively high encapsulation and favorable price. To be more specific, ECS (Elastic Compute Service) cloud server is more like an empty computer host, to use which the user needs to configurate CPU, memory, and setup operation system by himself. Compared with ECS cloud server, lightweight server is more friendly for beginners.

Figure 41: Transaction Interface of Lightweight Server

(2). Cloud server visualization and remote connection

Different from Windows or Mac operation system, Linux is not designed to run fancy desktop. However, it's better to realize a desktop which is useful for verifying the operation correctness.

X Window System is a graphic user interface, which provide user with a basic graphic user interface and abundant input device capability.

```
1. yum groupinstall "X Window System"
```

GNOME is a purely free set of computer software that runs on an operating system and provides a graphical desktop environment.

```
2.  yum groupinstall "GNOME Desktop"
```

X Window System and GNOME are two core components to realize the Linux visualization, besides there are series operation are adopted to realize the desktop completely which are shown in the blog.

XShell and **Xftp** two software are adopted to realize the remote connection and file transmission separately.

(3). Environment Configuration

Cloud server need to be configurated properly to run the website. Firstly, Python 3.8.2 and Django 3.0.1 were installed in the cloud server. Then SQLite 3.0 was installed to activate database function. Besides, the corresponding python libraries were installed into cloud server such as the tushare API which was applied by GBP Exchange Rate Monitoring module and Pandas which was applied by many functional modules to process data. The whole environment configuration process involves lots of debug works, **here the installation process of Python 3.8.2 is given below:**

- ***Install File Download Tool***
  wegt is adopted to achieve file download

```
1. yum -y install wget
```

- ***Download Python 3.8.2***

```
2. wget https://www.python.org/ftp/python/3.8.2/Python-3.8.2.tgz
```

- ***Uncompress Python Installation Package***

```
3. tar zxf Python-3.8.0.tgz
```

- ***Configurate Installation Path***

```
4. ./configure prefix=/usr/local/python3 --enable-optimizations
```

  – The prefix option is to configure the installation path. If this option is not configured, the executable file is placed in /usr/local/bin by default after installation, the library file is placed in /usr/local/lib by default, and the configuration file is placed in /usr/ by default. local/etc, other resource files are placed in /usr/local/share, which is messy.

- ***Install the Python 3.8.2***

```
5. make install
```

During this procedure, lots of bugs occurred.

- ***Debug 1***

```
Could not import runpy module
Traceback (most recent call last):
  File "/root/Python/Python-3.8.2/Lib/runpy.py", line 15, in <module>
    import importlib.util
  File "/root/Python/Python-3.8.2/Lib/importlib/util.py", line 14, in <module>
    from contextlib import contextmanager
  File "/root/Python/Python-3.8.2/Lib/contextlib.py", line 4, in <module>
    import _collections_abc
SystemError: <built-in function compile> returned NULL without setting an error
generate-posix-vars failed
make[1]: *** [pybuilddir.txt] Error 1
make[1]: Leaving directory `/root/Python/Python-3.8.2'
make: *** [profile-opt] Error 2

```

Figure 42: Bug 1 of Python Installation

This bug is due to the low gcc version (The version of gcc 8.0 or above is needed). To tackle this problem, --enable-optimizations parameter was removed and use:

```
6. ./configure prefix
```

However, another problem occurred.

- ***Debug 2***

```
Could not import runpy module
Traceback (most recent call last):
  File "/root/Desktop/Python/Python-3.8.2/Lib/runpy.py", line 15, in <module>
    import importlib.util
  File "/root/Desktop/Python/Python-3.8.2/Lib/importlib/util.py", line 14, in <module>
    from contextlib import contextmanager
  File "/root/Desktop/Python/Python-3.8.2/Lib/contextlib.py", line 4, in <module>
    import _collections_abc
SystemError: <built-in function compile> returned NULL without setting an error
generate-posix-vars failed
make: *** [pybuilddir.txt] Error 1
```

Figure 43: Bug 2 of Python Installation

This problem is due to the unproper language symbol compilation. Finally the code shown below was applied to solve all the problems:

```
7. ./configure --prefix=/usr/local --enable-unicode=ucs4 --enable-
shared LDFLAGS="-Wl,-rpath /usr/local/lib"
```

Then after creating soft connection, Python 3.8.2 and pip3 are good to use.

(4) Port configuration

Open specific port in the firewall to allow user access the website throw public net IP, and allow remote visualized connection.

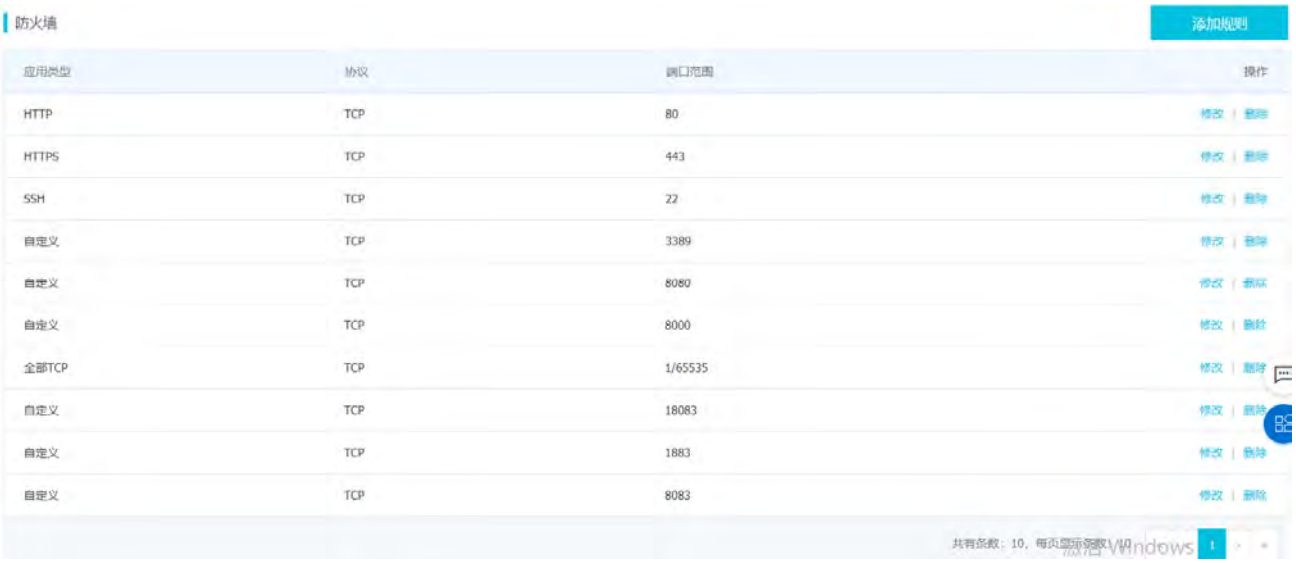


Figure 44: Port Configuration of The Cloud Server

Port Number	Purpose
80/8080	Allow user access the cloud server through Public Net IP
3389	Allow local Windows connect to cloud server remotely
18083	MQTT Management Interface
1883	Allow other application connect to MQTT server
8083	Allow other web function connect to MQTT server
8000	The port associated with website

Table 8: The Usage of Ports

3.2.5.2 Website Migration and Startup

After setting up the cloud server, the website project needs to be migrated to the cloud server.

(1). File Transmission

Firstly, Xftp was applied to transfer the whole Django file from the local computer to the cloud server. Then a series of instructions are adopted to activate the project.

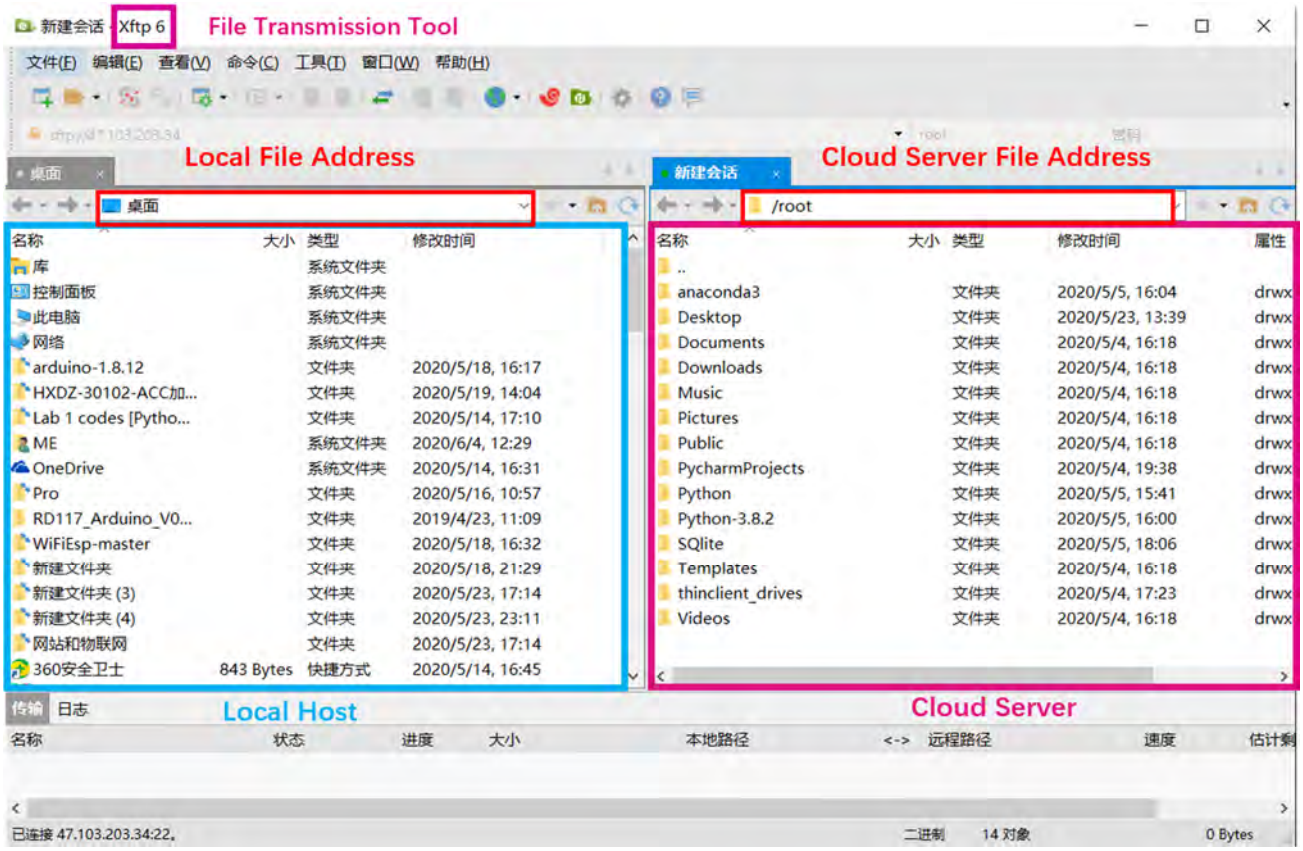


Figure 45: File Transmission Tool

(2). Web Migration and Modification

```
python3 manage.py migrate
```

This line of code is used to activate the modules in Django (admin, auth, contentypes, picturehub, sessions and userhub). The code below is used to combine the public net IP and the 8000 port together, so that user can access the website by accessing the 8000 port of the public net IP of the cloud server.

```
python3 manage.py runserver 0.0.0.0:8000
```

Then add the public net IP of the cloud server to the setting.py to allow website receive the requests arrived at the public net IP. Besides, all the URLs in the Ajax functions that are associated with back-end, were modified to access the back-end through public net IP.

(3). Web Startup

To Let the website run on cloud server constantly, screen module is applied. Screen is a software developed by the GNU for command line terminal switching. Users can connect multiple local or remote command line sessions at the same time through this software and switch freely between them. By adopting screen, the website can run constantly without being influencing by other sessions.

3.3 Internet of Things

3.3.1 Outline

Internet of Things technique is applied to realize the communication between the back-end and the front-end. WIFI module, MQTT server and Python monitoring program are three main components of this section. A simple version and related details are shown in blog (IoT blog) The whole process is shown below:

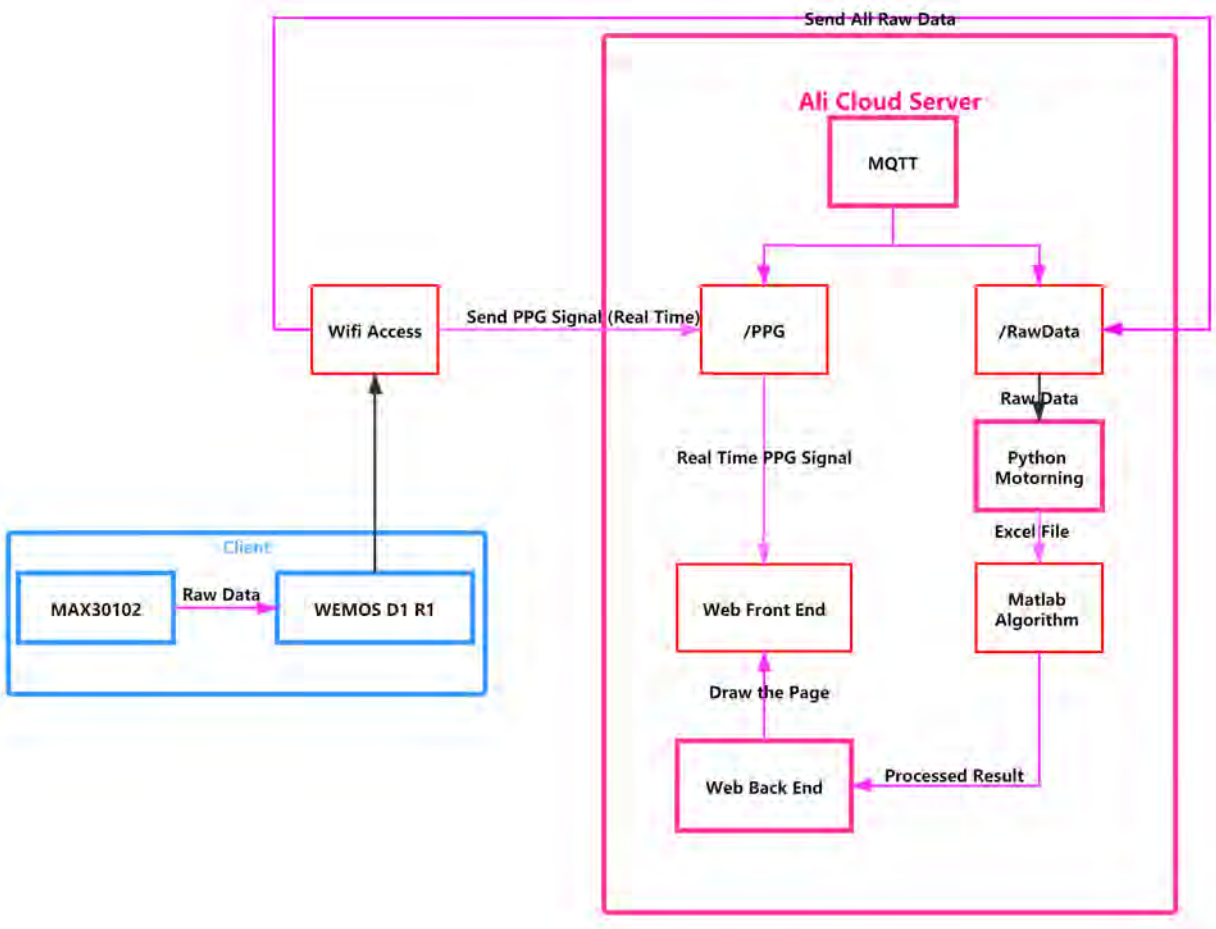


Figure 46: Diagram of IoT Process

Components	Description
MAX30102	Measure the PPG signal
WEMOS Development Board	Provide WIFI access function
MQTT Server	Implement message queuing telemetry transport protocol. Serving as an intermediate transmission medium
Python Monitoring Program	Receive the raw data and store them in a .csv file
MATLAB Algorithm	Process the data store in the .csv file further
Web Back-end	Receive the calculated index, heart rate, body oxygen level, and render them on the page
Web Front-end	Receive all the raw data and display the PPG signal on the page in real-time.

Table 9: Essential Components of IoT Technique

MAX30102 module is adopted to measure the PPG signal, which will send the raw data to the WEMOS development board. WEMOS D1, which has been integrated the ESP8266 WIFI module, is applied to send the raw data to two subtopics of MQTT server. The Ajax function written in front-end receive the raw data and display them to user in real-time. At the same time, the python monitoring program, which subscribed the topic 2, receive all the raw data and store them in a .csv file. Then the MATLAB Algorithm is called by the python monitoring program and process the data store in the .csv file. Finally, the back-end of the website receive the results and render the health analysis result subpage again.

Note that, both MQTT server, Python monitoring program and web running on the cloud server.

3.3.2 WIFI Access

3.3.2.1 Hardware Description

The first step is that let the portable device connect to the internet. WEMOS D1 development is chosen to realize WIFI access function.

Figure 47: WEMOS D1 WIFI UNO R3

WEMOS D1 development board integrate the ESP-12E WIFI module and is compatible with Arduino.

Processor	**ESP-8266EX**
Working voltage	3.3V
Input voltage	6-24V
I/O number	11
AD input voltage	0-3.3V
Flash	4MB
SRAM	32KB
DRAM	80KB
Clock Frequency	80MHz/16MHz

Table 10: Technical Parameter of Develop board

Pin	**Description**	**IC Interior Pin**
D0	RX	GPIO3
D1	TX	GPIO1
D2	I/O	GPIO16
D3/SCL/D15	Clock Signal Line of I2C bus	GPIO5
D4/SDA/D14	Data Signal Line of I2C bus	GPIO14
D5/SCK/D13	I/O, Clock of SPI	GPIO12
D6/MISO/D12	I/O, MISO of SPI	GPIO13
D8	I/O, Pull-Up, Flash mode (at low level)	GPIO0
D9/TX1	I/O, Pull-Up	GPIO2
D10/SS	I/O, Pull-Down	GPIO15
A0	AD input, 0-3.3v	ADC

Table 11: Pin Description

3.3.2.2 Integrated Development Environment Configuration

To let WEMOS development board execute the Arduino program properly, a series of processes were adopted.

(1). Development Board Manager Configuration

Add the URL: http://arduino.esp8266.com/stable/package_esp8266com_index.json to the development board manager URL. This URL allows user download the 8266 modules (the .json data collect the URLs of ESP8266 modules' components).

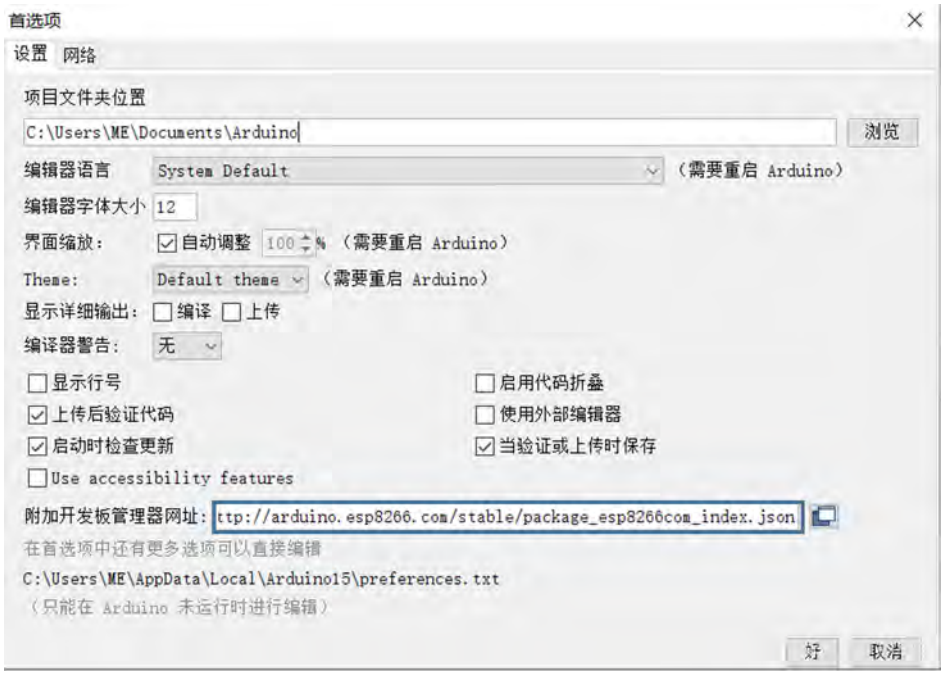


Figure 48: Development Board Manager Configuration

(2). Download the Related Libraries

Download the related libraries to the appointed address:

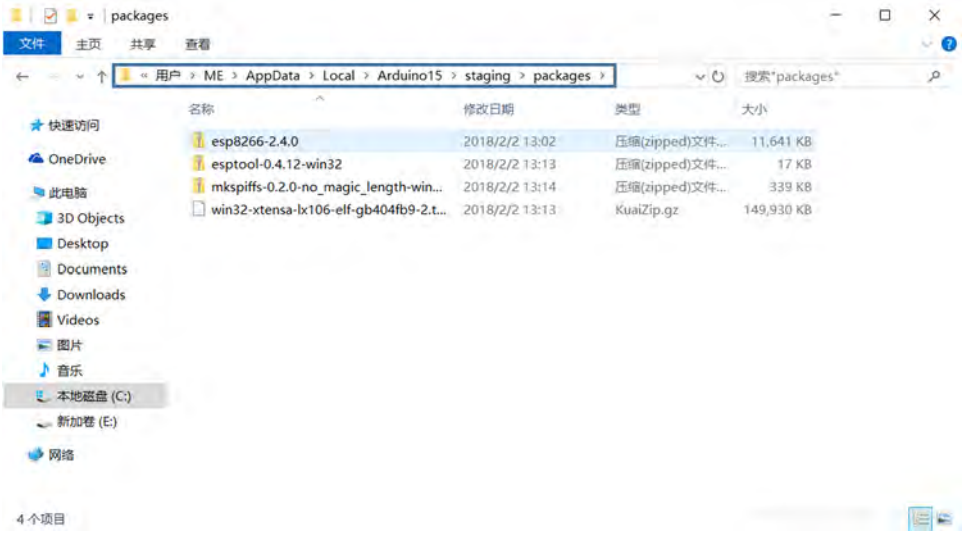


Figure 49: ESP8266 Libraries

Note that, the address should be set correctly, otherwise the libraries cannot be called.

(3). Download the ESP8266 Module

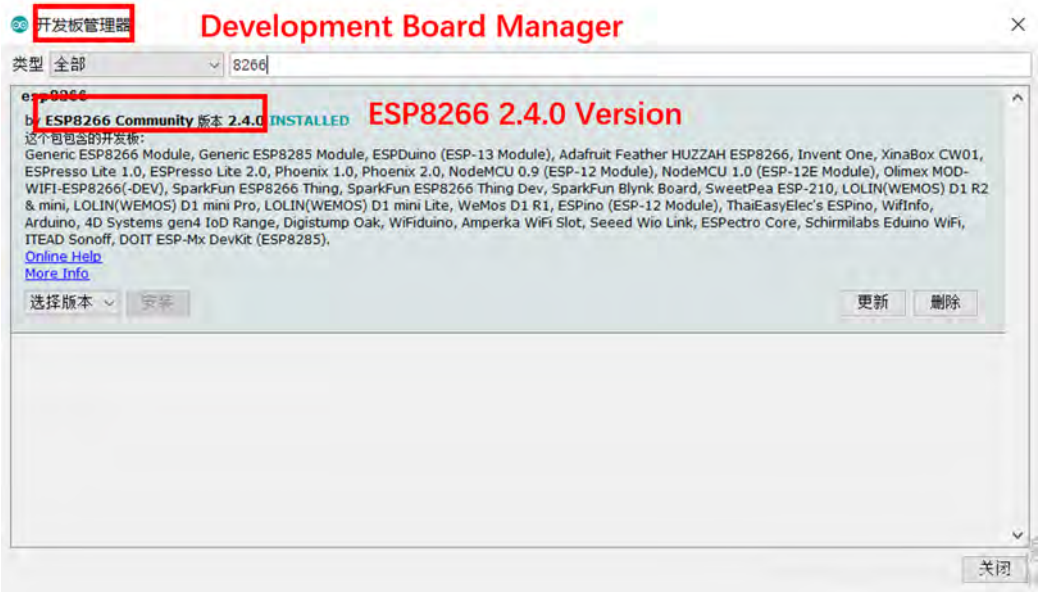


Figure 50: Download ESP8266 Module

(4). Use WEMOS DI R1 Development Board

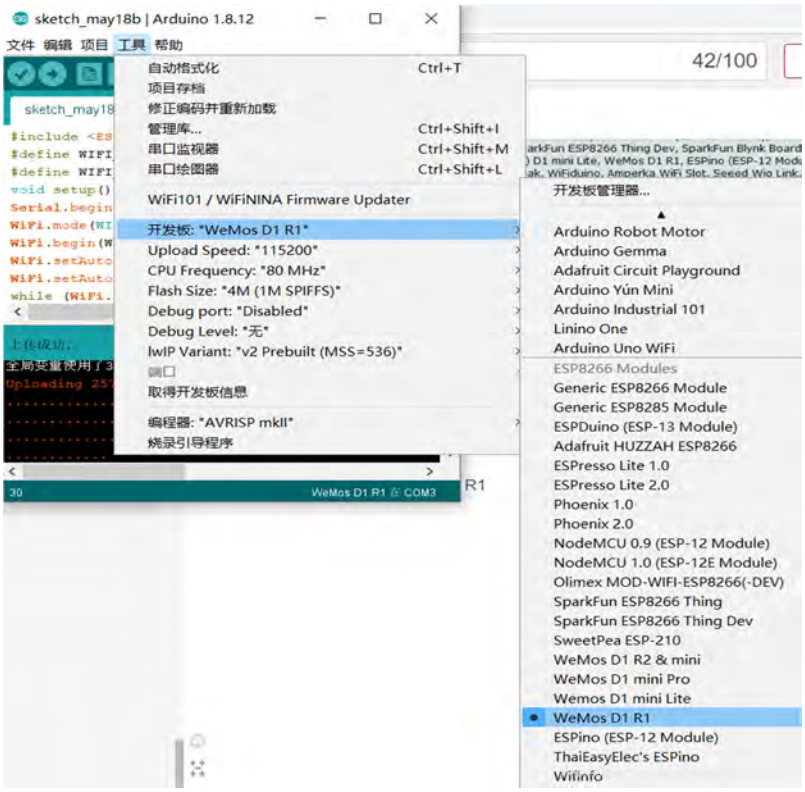


Figure 51: Choose Development Board

(5). Other Configurations:

Figure 52: Other Configuration

After configuration the WEMOS development board can connect to internet through WIFI module successfully.

3.3.3 Monitoring Program

This module is designed to receive raw data from MQTT server, store them in to a .csv file as well as call MATLAB Algorithm module to process the data stored in .csv file further.

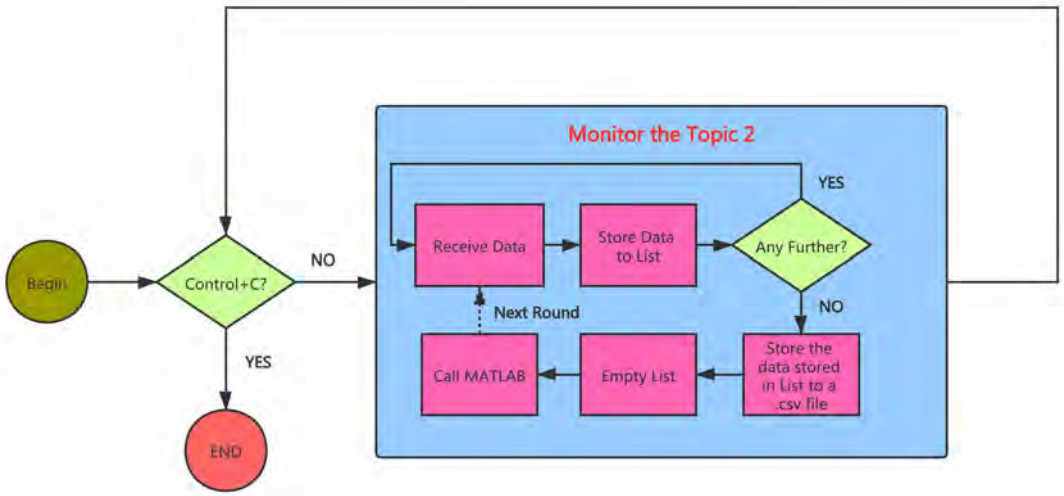


Figure 53: Monitoring Program Diagram

3.3.4 MQTT Server

MQTT (Message Queuing Telemetry Transport) is a message transfer protocol, based on publish/subscribe mode. On account of its characters of lightweight, convenient for using and easy to implement, MQTT has been widely applied in instant messaging, IoT, and M2M fields. In this project, Erlang MQTT Broker serves as an intermediate message media, through which the portable device can communicate with the applications running on cloud server successfully.

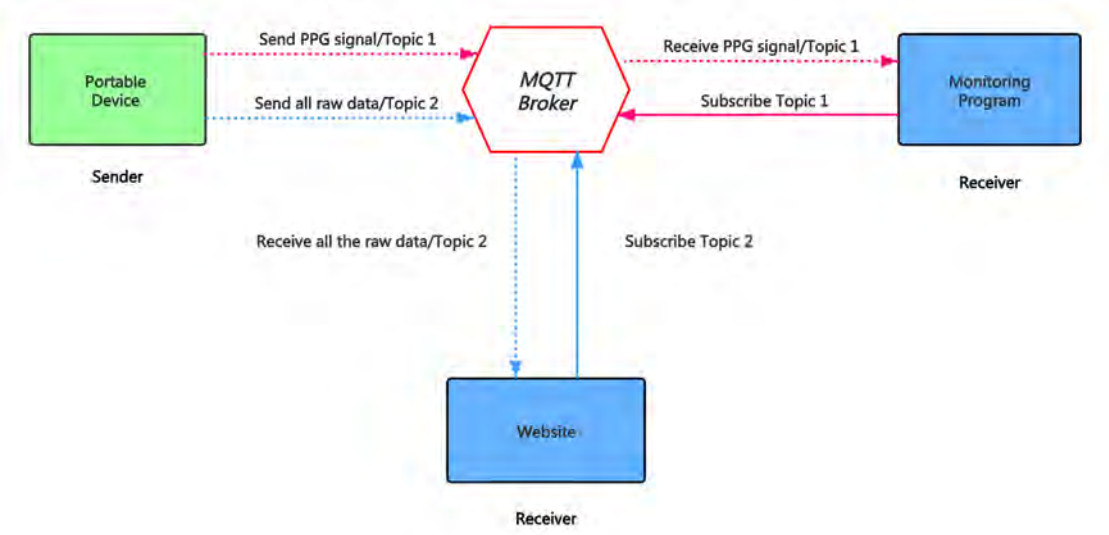


Figure 54: MQTT Broker Application

There are three sessions, when portable device connects to MQTT Broker through WIFI module. There are two topics in charge of two different data transmission processes.

The MQTT server setup process is shown below:

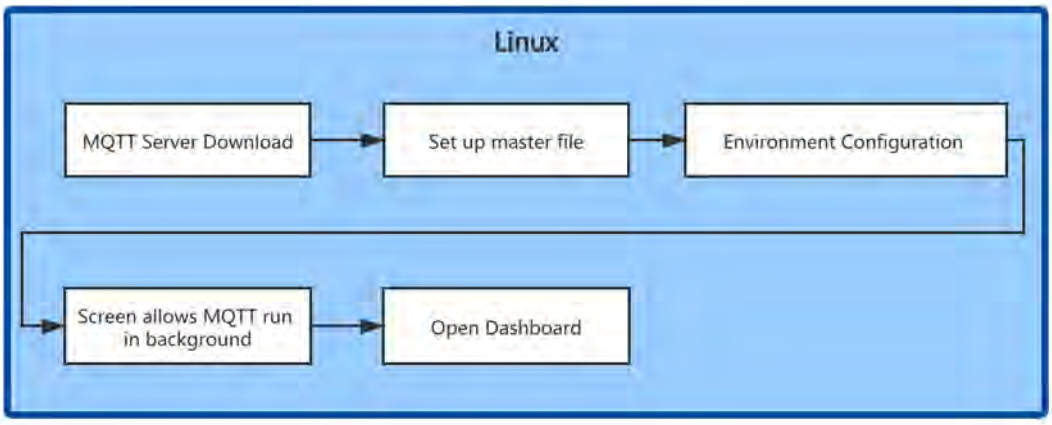
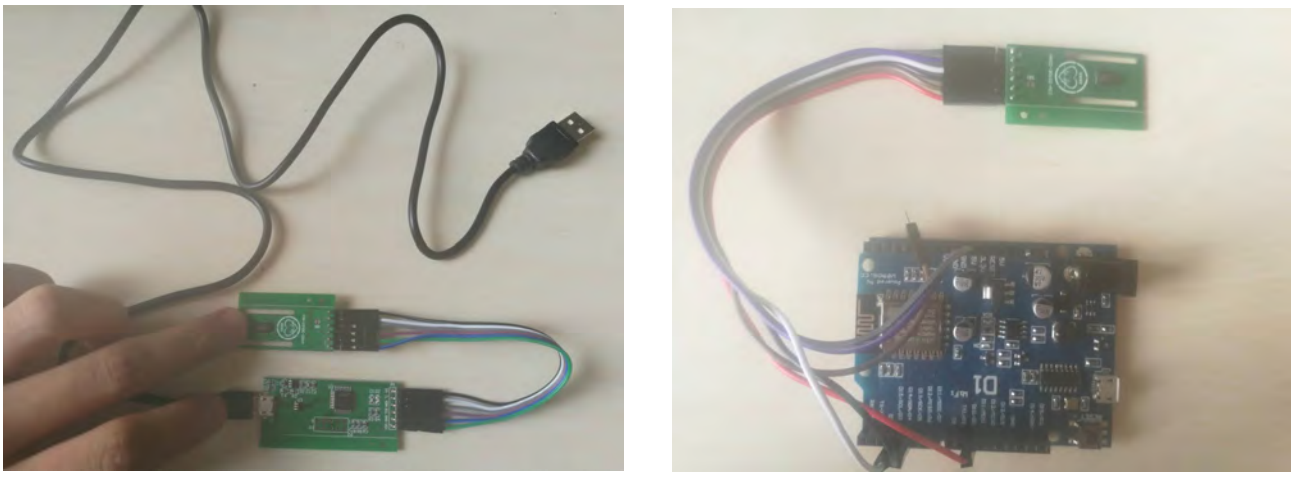


Figure 55: EMQ Setup

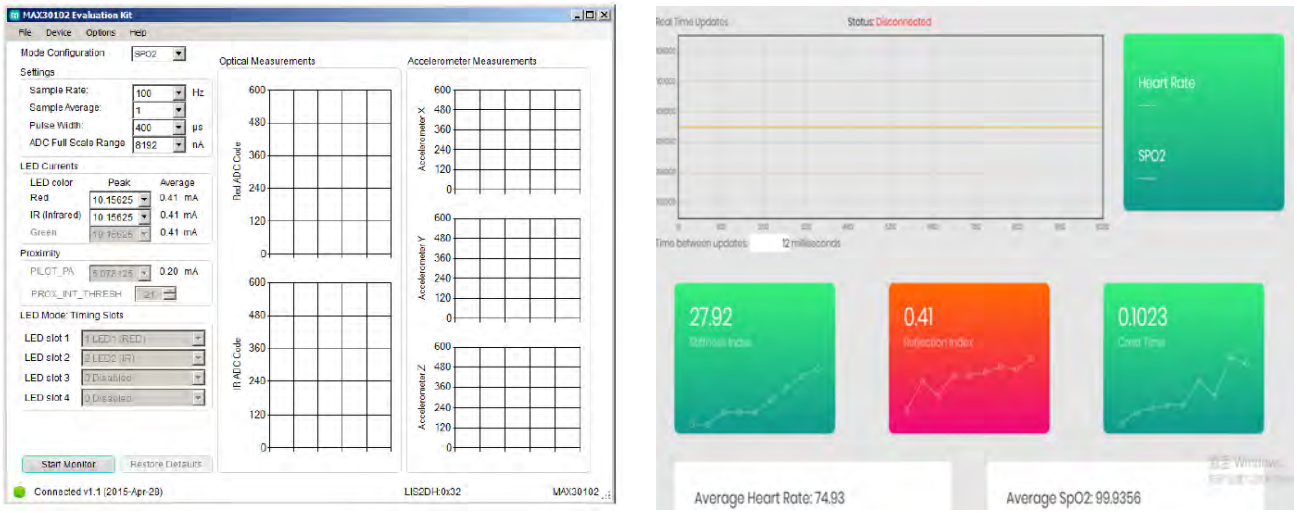
4. Result and Discussion

4.1 Portable Device and Monitoring Interface



(a). Portable Device (First Version) **(b). Portable Device (Current Version)**

Figure 56: Portable Device



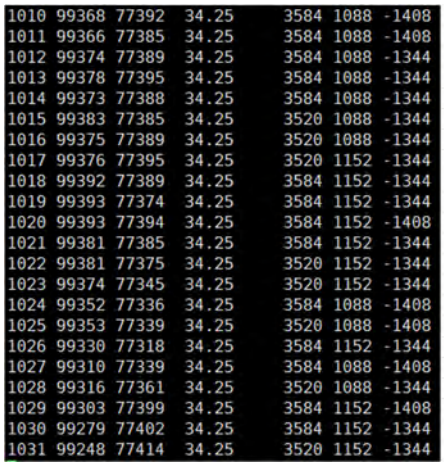
(a). Upper-computer Software **(b). PPG Signal Display Window**

Figure 57: Monitoring Interface

The First version uses a USB cable for data transmission which means users have to sit beside the computer when they measure their body signal. Besides, to use the first version, an upper-computer software has to be downloaded. The Current version adopt WIFI module for data transmission, and applies a full-featured website to display PPG signal in real-time. Note that, user can access the website with laptop, smartphone, tablet or whatever equipment they want. Compared with the first version, the current version has got rid of measurement limitation and access limitation, which is more user-friendly.

4.2 Health Analysis Intermediate Result

4.2.1 Data Acquisition



1010	99368	77392	34.25	3584	1088	-1408
1011	99366	77385	34.25	3584	1088	-1408
1012	99374	77389	34.25	3584	1088	-1344
1013	99378	77395	34.25	3584	1088	-1344
1014	99373	77388	34.25	3584	1088	-1344
1015	99383	77385	34.25	3520	1088	-1344
1016	99375	77389	34.25	3520	1088	-1344
1017	99376	77395	34.25	3520	1152	-1344
1018	99392	77389	34.25	3584	1152	-1344
1019	99393	77374	34.25	3584	1152	-1344
1020	99393	77394	34.25	3584	1152	-1408
1021	99381	77385	34.25	3584	1152	-1344
1022	99381	77375	34.25	3520	1152	-1344
1023	99374	77345	34.25	3520	1152	-1344
1024	99352	77336	34.25	3584	1088	-1408
1025	99353	77339	34.25	3520	1088	-1408
1026	99330	77318	34.25	3584	1152	-1344
1027	99310	77339	34.25	3584	1088	-1408
1028	99316	77361	34.25	3520	1088	-1344
1029	99303	77399	34.25	3584	1152	-1408
1030	99279	77402	34.25	3584	1152	-1344
1031	99248	77414	34.25	3520	1152	-1344

(a) Monitoring Program (b) .csv File Stored by Monitoring Program

Figure 58: Raw Data

Time	Raw IR	Raw Red	Raw Green	Temperature	Heart Rate	SPO2	X	Y	Z

Table 12: Record Attributes

The raw data are got by web-front end and Python monitoring program separately, after receiving all the raw data, the data was stored in a .csv file in cloud server.

4.2.2 Pre-processing

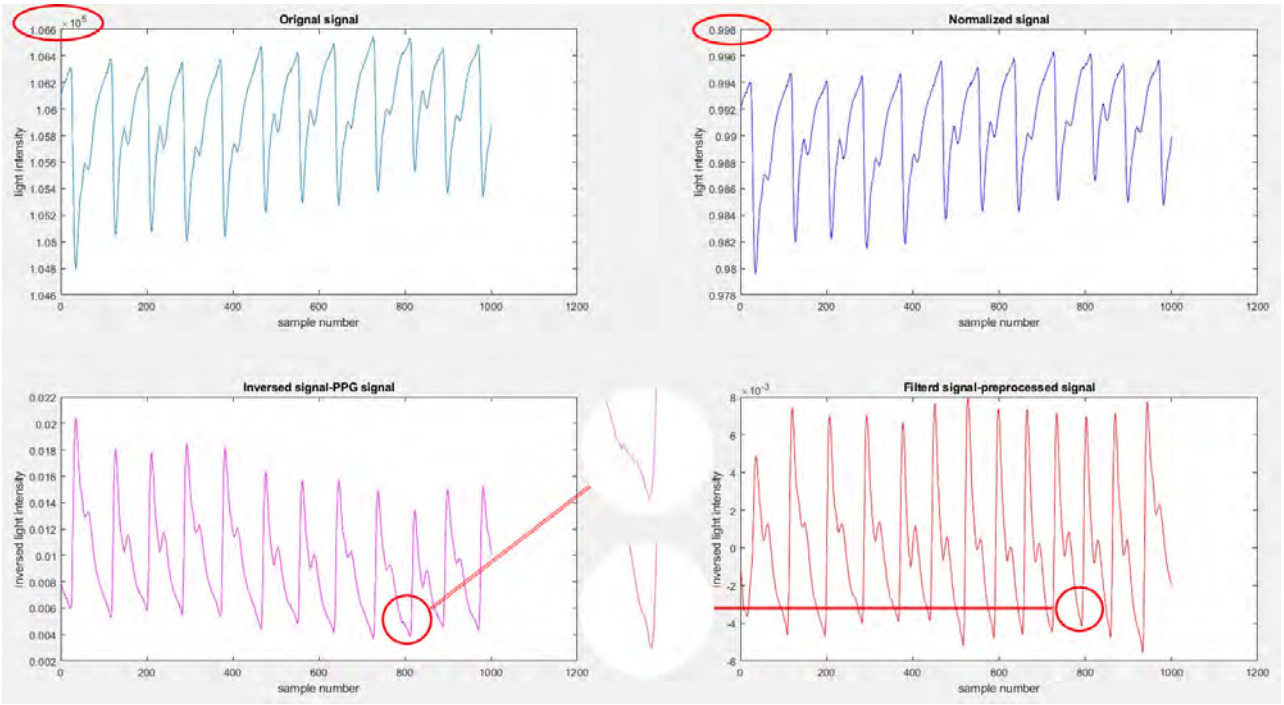
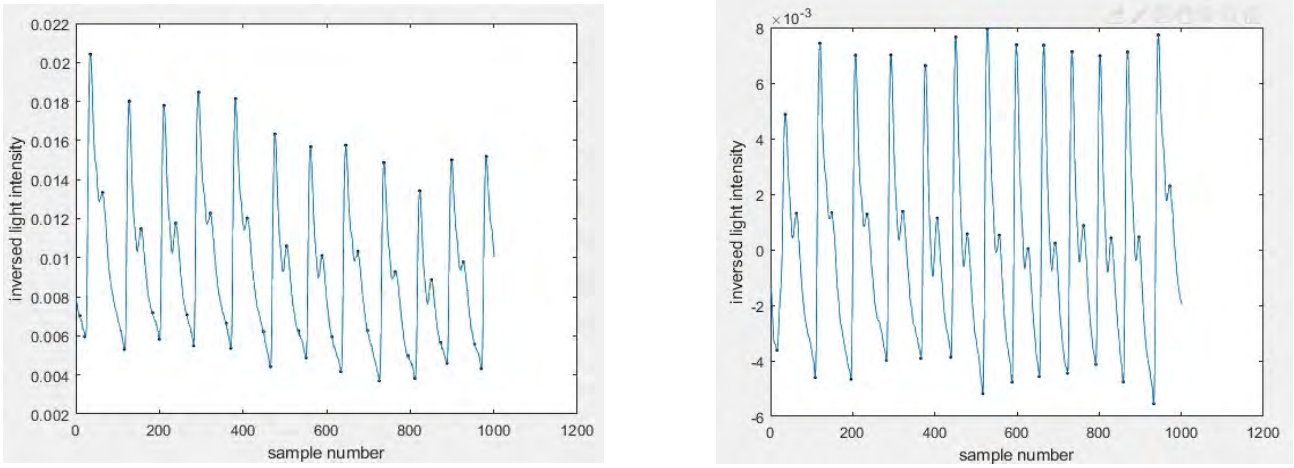


Figure 59: Pre-processing Result

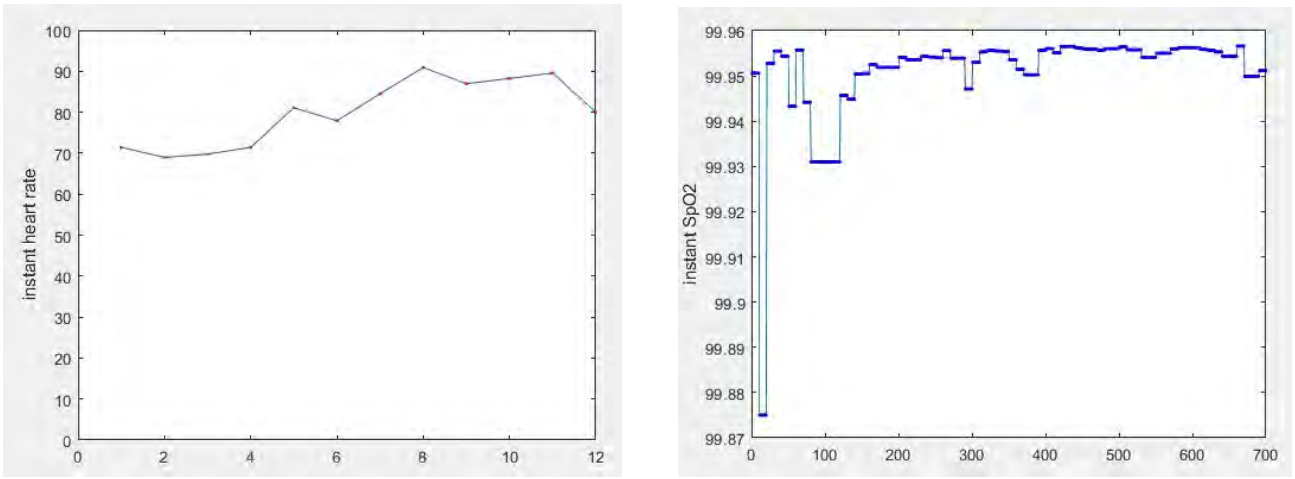
According to Figure 58, after passing filter the PPG signal become smoother which is important for peak detection to obtain correct peaks and valleys. The difference of peak detection for original signal and unfiltered signal is shown below. Note that to make the results clearer, just 12 period of signal were selected.



(a). Peak Detection of Unfiltered Signal (b). Peak Detection of Filtered Signal

Figure 60: Comparison of peak detection results

4.2.3 Cardiac Evaluation and SpO2 Algorithms Result



(a). Instantaneous Heart Rate (b). Instantaneous SpO2

Figure 61: Algorithm Results

Note that to show the result clear just 1200 points were applied (the measure time was about 90 seconds and there were 9000 points in total). The results are with good accuracy. From the instantaneous heart rate graph, arrhythmia and relevant disease may be discovered.

4.2.4 Vessel Evaluation Result

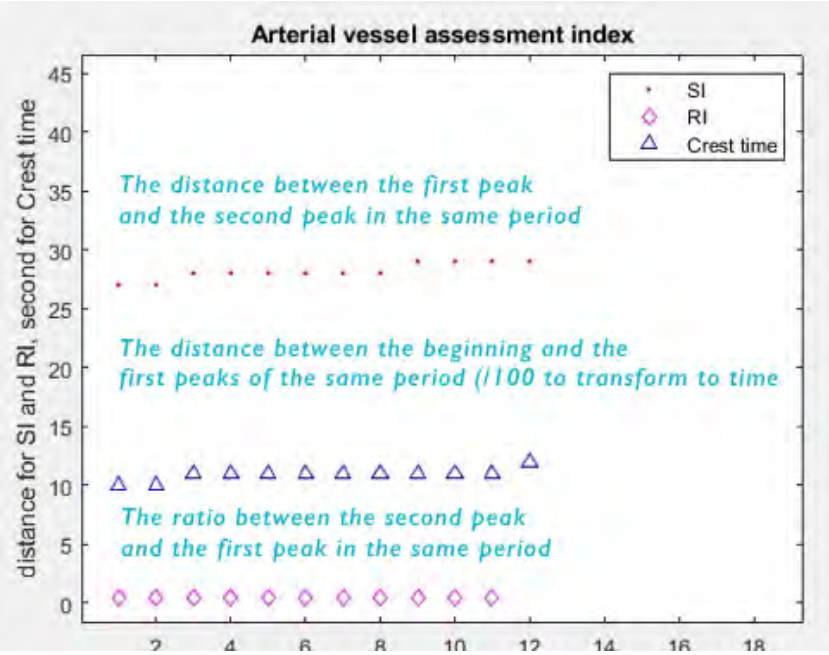


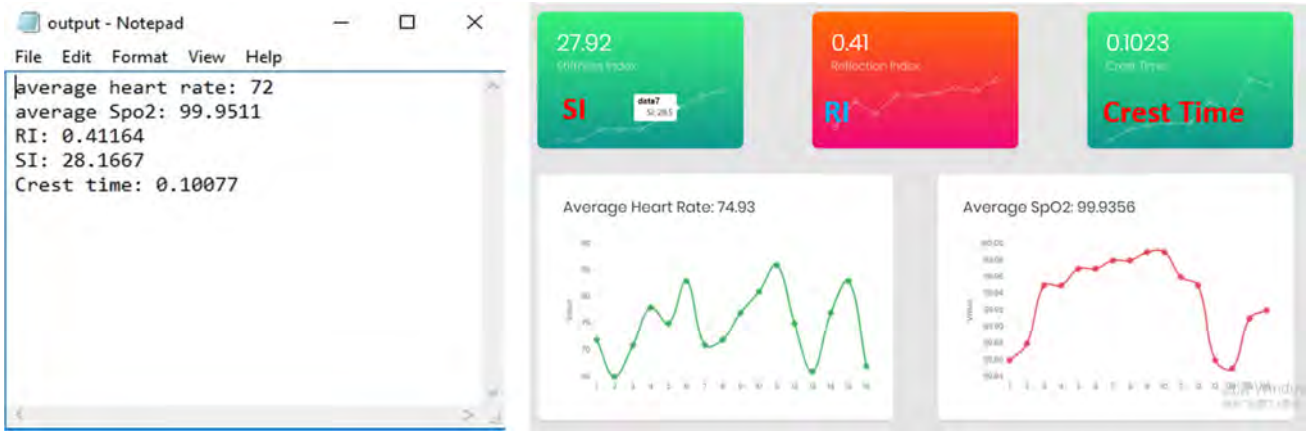
Figure 62: Arterial Vessel Assessment Results

Compared with healthy subjects, the crest time of subjects with arterial sclerosis is longer. Besides, during arteriosclerosis process, the resistance will increase and the capacity will decrease which will lead to the decrease of Reflection Index. Meanwhile, the arteriosclerosis procedure will lead to low artery compliance and the increase of Stiffness Index.

Index	**Average Value**
Crest Time	0.10077 (Normal Level)
Stiffness Index	28.1667 (Normal Level)
Reflection Index	0.41164 (Normal Level)

Table 13 : Indexes Values

4.3 Health Analysis Result



(a). Output Report (First Version) (b). Health Analysis Result Subpage (Current Version)

Figure 63: Health Analysis Result

Note that the unit of SI is m/s, the unit of RI is 1 (because it is a ratio) and unit of crest time is seconds.

Compared with the First version, the current version provides user more information, user can access each data point of the graph by moving their mouse to the point. Besides, the current version provides user an elegant interface and great convenience. Note that, the datasets of the Figure 62 (a) and (b) are different, to be more specific, the result of (a) is on the basis of 1200 data point and the result (b) is on the basis of about 12000 data points. The relative accurate result of Figure 62 (b) proves the MATLAB algorithm is stable and available even though relatively long signal is processed.

4.4 Website Display

Website Address: http://47.103.203.34:8000/

Username: ace Password: ace, ***Refresh after clicking button***.

Subpage	**URL**	**Description**
Login System	http://47.103.203.34:8000/	Beginning of the website
Personal Home Page	http://47.103.203.34:8000/picturehub/index	Functional Subpage
Smoking Cessation Hub	http://47.103.203.34:8000/picturehub/alert	Psychological Therapy
Health Analysis Result	http://47.103.203.34:8000/picturehub/list	Display Health Analysis Result

Table 14: Subpages and Descriptions

4.4.1 Login System

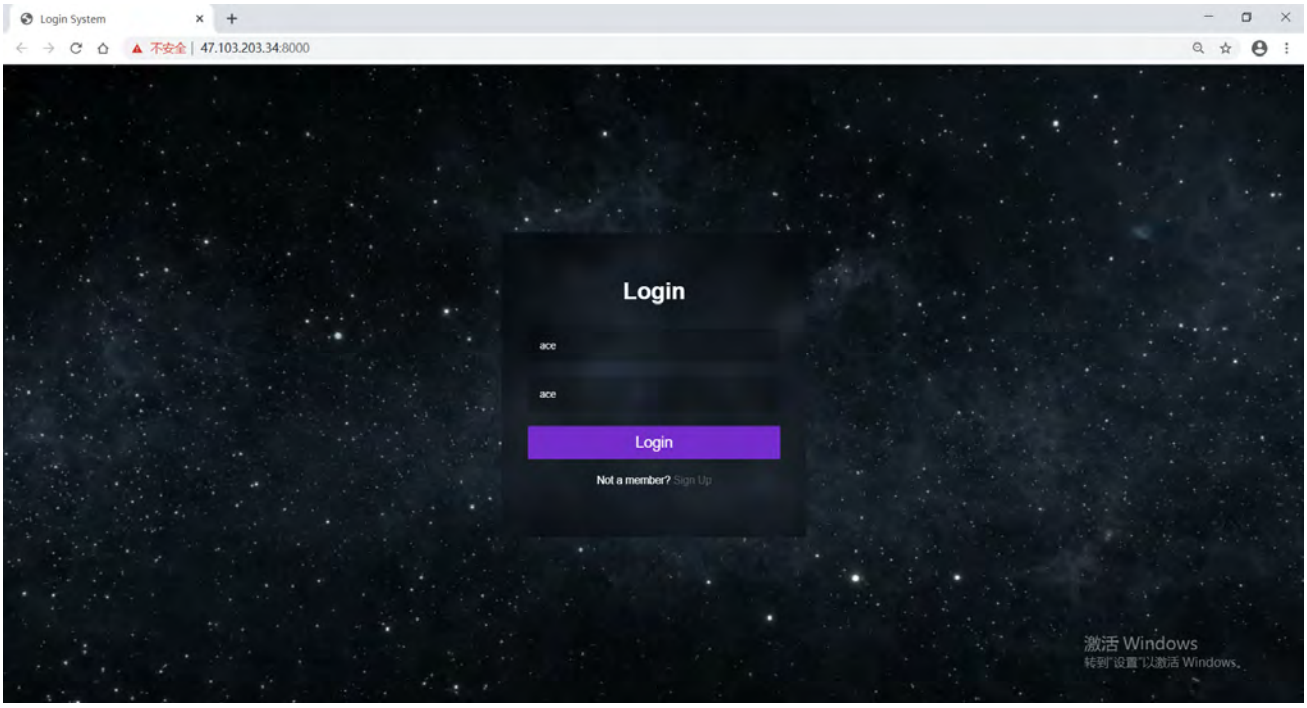


Figure 64: Login System Display

This page is the beginning of the whole website and it is the foundation of the customized services. The health analysis result and other personalized setting are all on the basis of the login system.

4.4.2 Page Aggregation

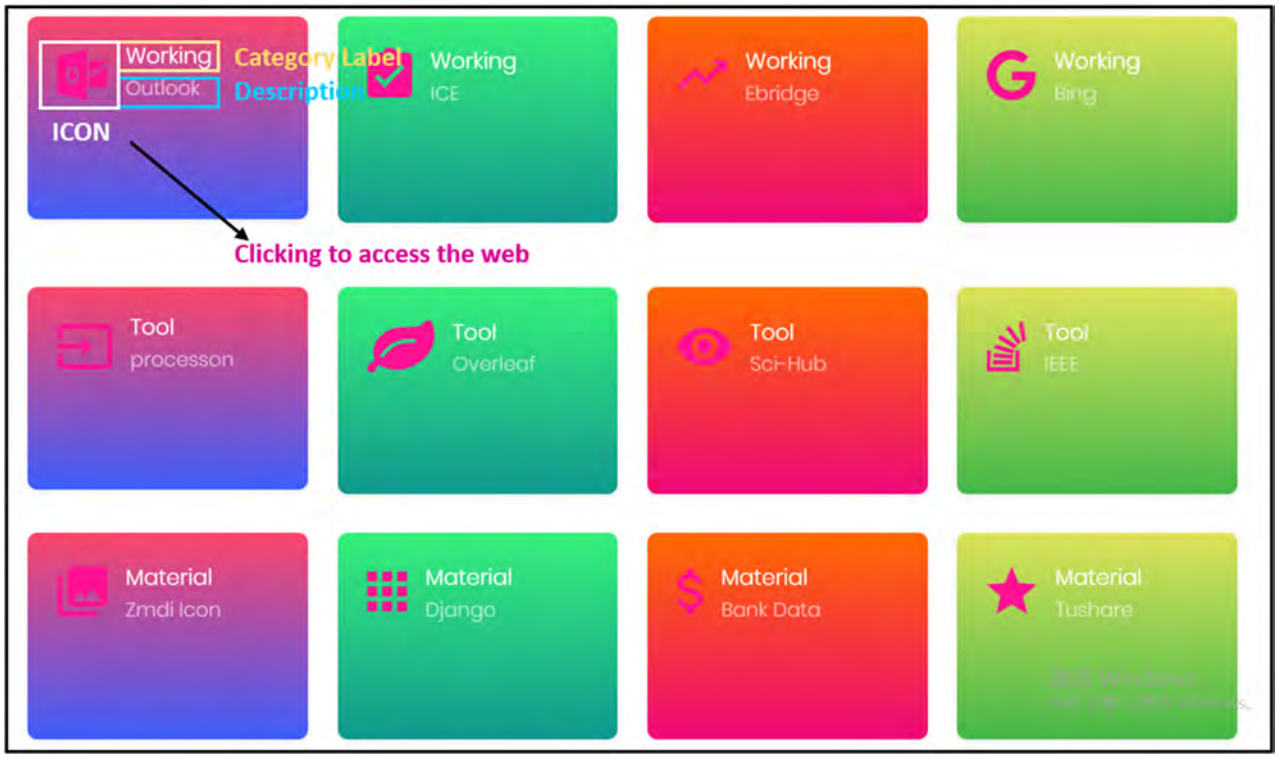


Figure 65: Page Aggregation

4.4.4 Static Graphs

Figure 66: Interactive Static Graphs

Different with traditional graphs, this set of statistical graphs are interactive elements, which means it will show different information according to user's operations. Through this set of questions and statistical data, smoker can have a better recognition about why they smoke, why they failed and why they can't quit and so on, which is actually the first step of the psychological therapy.

4.4.5 Smoking Cessation Benefits Display Bar

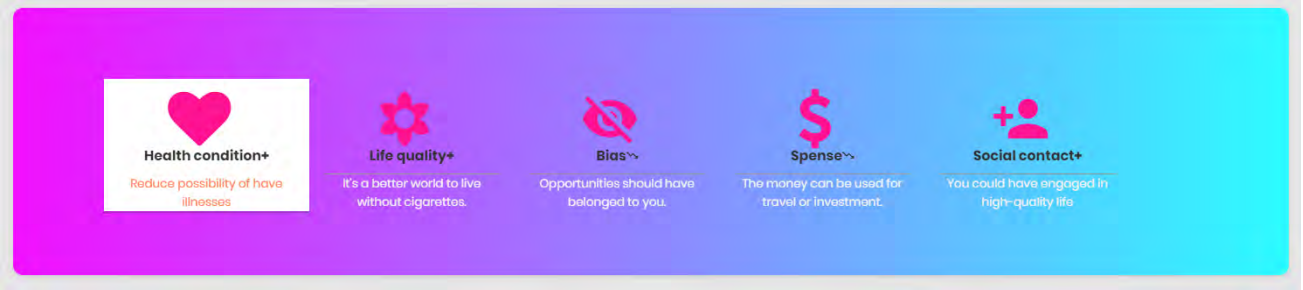


Figure 67: Smoking Cessation Benefits Interactive Element

4.4.6 No Reason Module

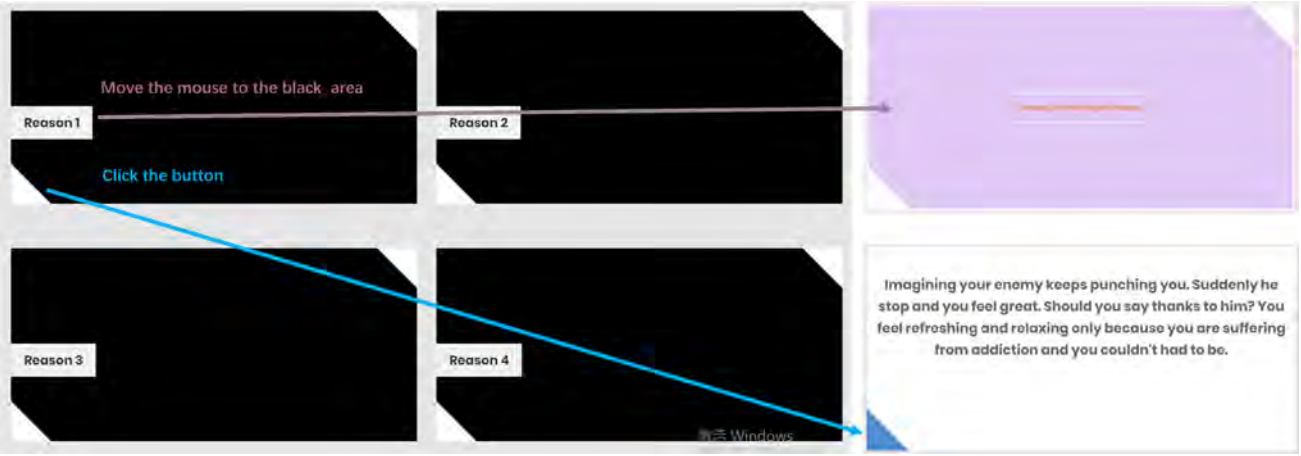


Figure 68: No Reason Module

This module is designed to help smokers realize the seemingly reasonable reasons for not quit the habit are all excuses. This module is also an interactive design, by moving the mouse to the black area or clicking the button, different information will be displayed in different styles.

4.4.7 One Reason Module

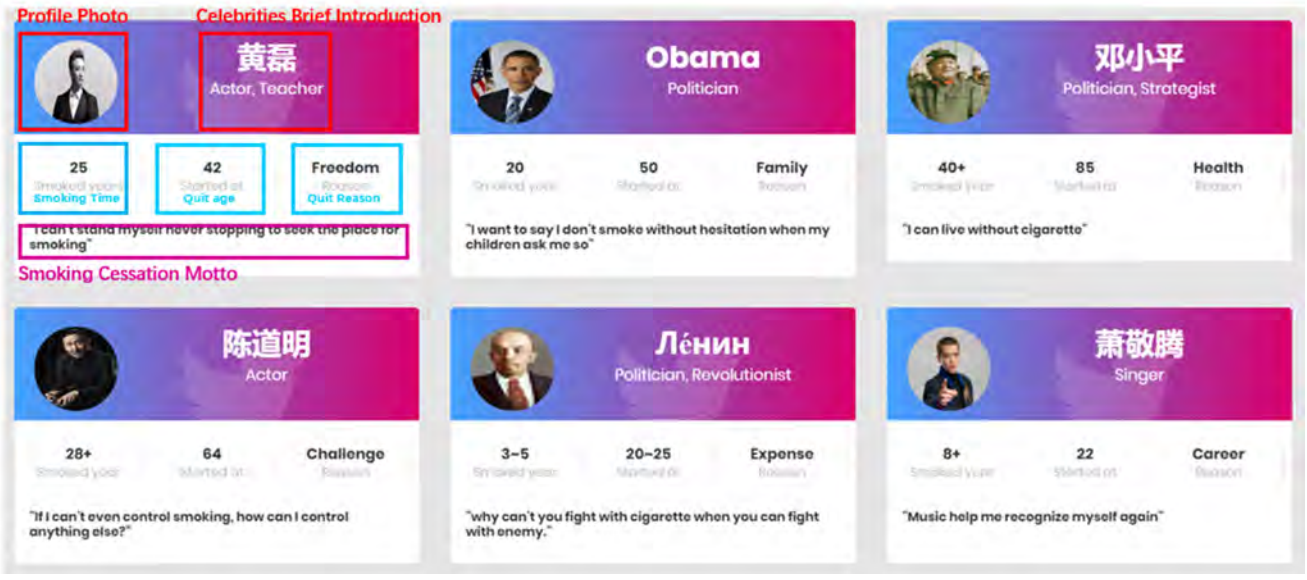


Figure 69: One Reason Module

This module is designed to help smokers find a strong motivation to quit the habit by introducing a series of quit reasons of many celebrities who have quit the habit. By clicking the profile photo, the user can access the smoking cessation story of the celebrity in the pop-up window. The pop-up window is shown below:

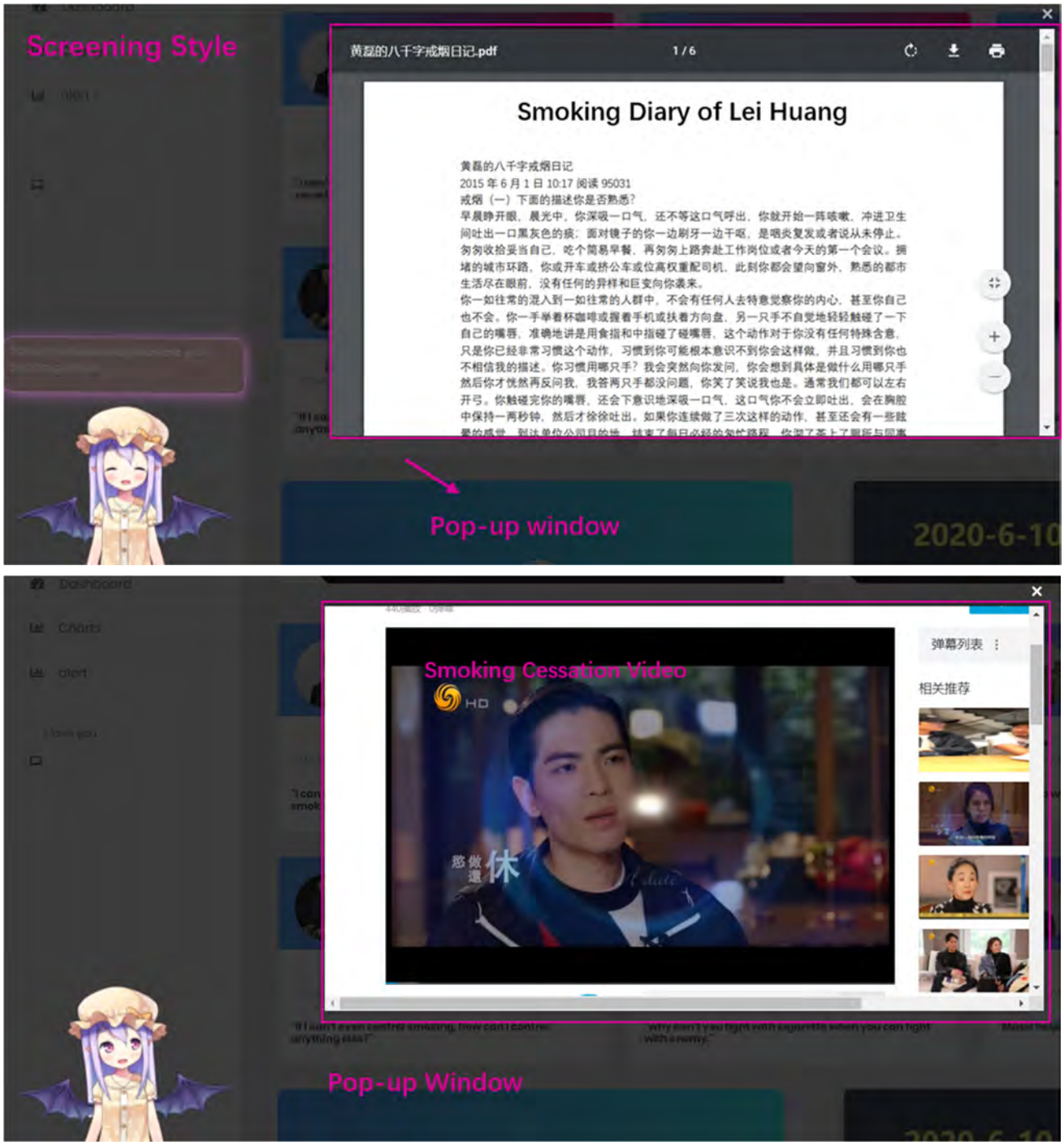
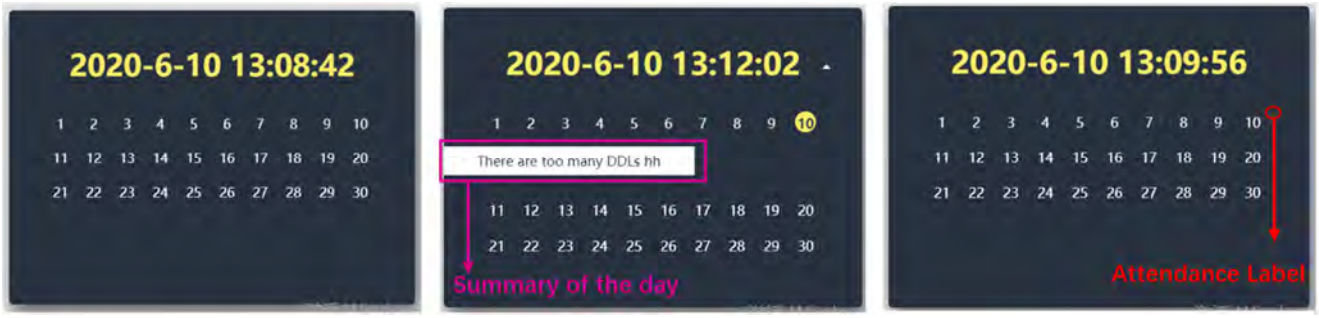


Figure 70: Pop-up Window and Smoking Cessation Stories

When the user clicks the profile photo of a certain celebrity, the page will go into the screening style and the smoking cessation story of the celebrity will be shown in a pop-up window. Pop-up window allows user watch the video or picture in the page, rather than go into another web through URL. Besides, the screening style has a good visual effect.

4.4.7 Attendance System



(a). Interface (b). Comment Function (c). Attendance Label

Figure 71: Attendance System

The Attendance System is not perfect yet. Sometimes it is hard for users to close the comment input box.

4.4.8 Diary System

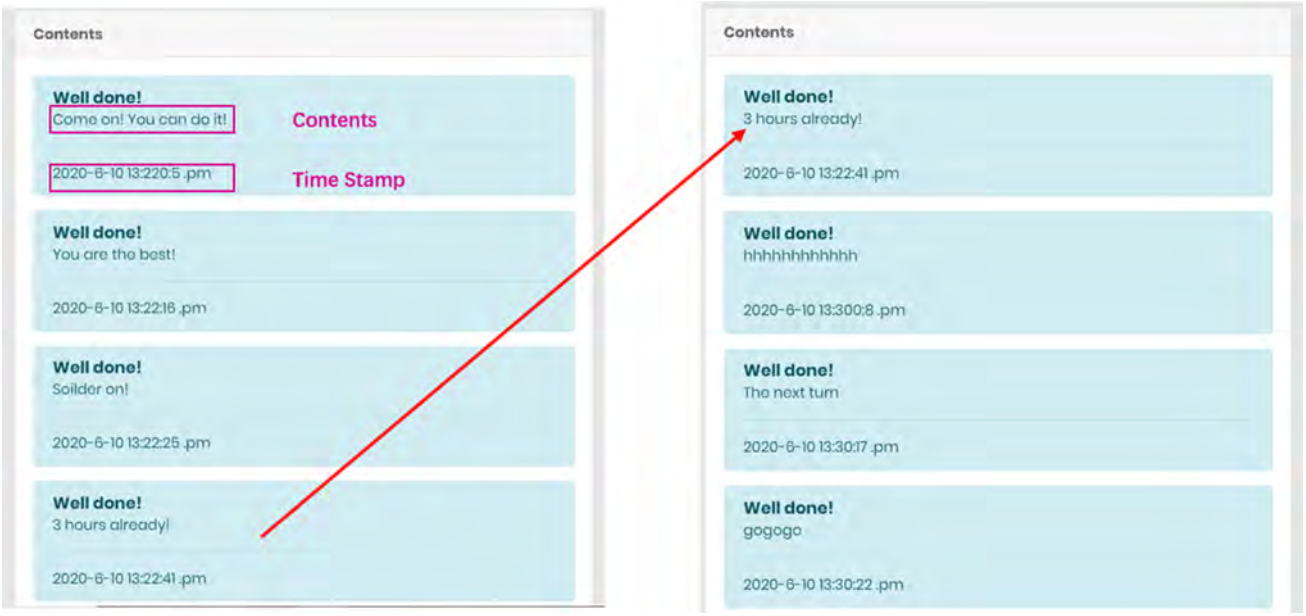
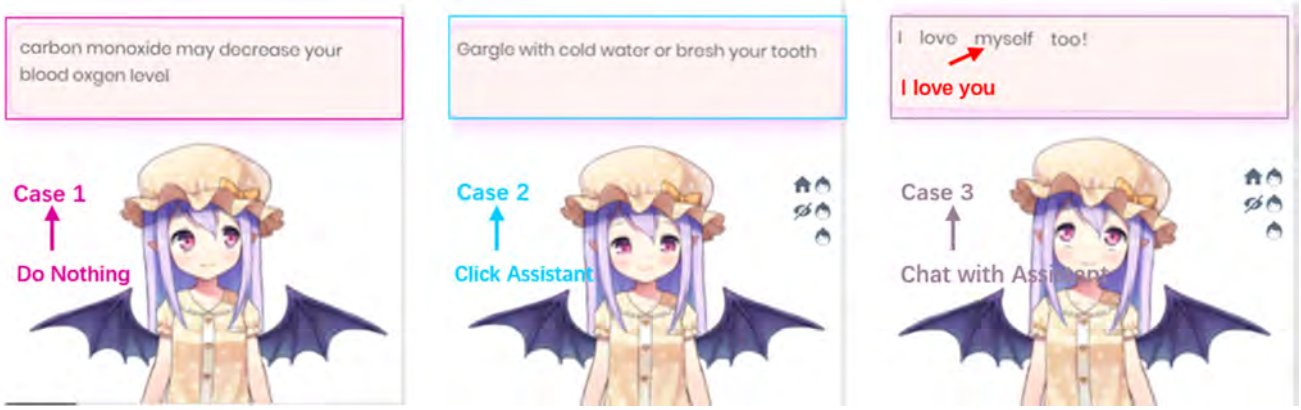


Figure 72: Diary System

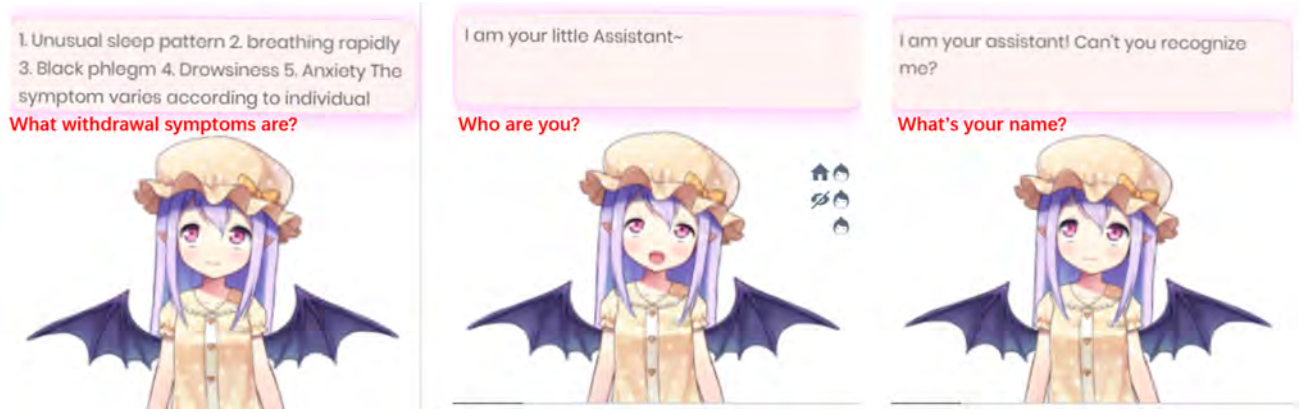
The Diary System allows the user record their smoking cessation progress. However, currently, the diary will not be stored in the database, but display in rolling form (as shown above).

4.4.9 Intelligent Personal Assistant



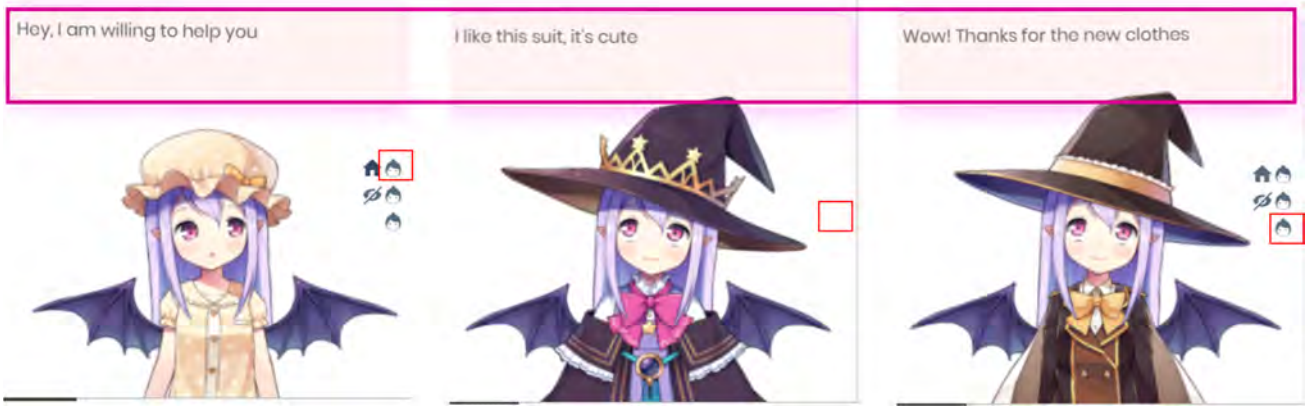
(a). Function 1 (b). Function 2 (c). Function 3

Figure 73: Intelligent Assistant Function Display



(a) Dialogue 1 (b). Dialogue 2 (c). Dialogue 3

Figure 74: Communication Display



(a). Suit 1 (b). Suit 2 (c). Suit 3

Figure 75: Intelligence Assistant Appearances

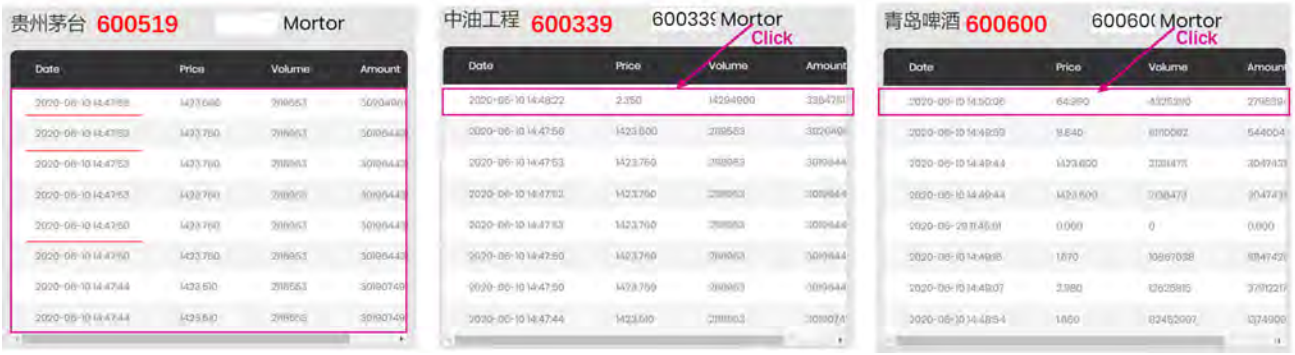
4.4.10 Intelligent Personal Assistant

(a). GBP Monitoring (b). Data Source (Bank of China)

Figure 76: GBP Exchange Rate Monitoring Program

The GBP Exchange Rate is climbed down from bank of China official website for each second, by applying web crawler technique and AJAX technique. Note that the whole processes are down automatically. Note that, GBP can be replaced by other currencies through a small code modification.

4.4.11 Stock Tracking Program



(a). Kweichow Moutai (b). PetroChina (c). Tsingtao Beer

Figure 77: Stock Tracking Program

The default stock code is 600519 (Kweichow Moutai), and user can track a specific stock by inputting the corresponding stock code. Besides, the stock information will refresh in each 5 minutes (can be reset), and user can acquire the latest stock information by clicking the monitor button.

4.4.12 Coronavirus and NBA Monitoring Program

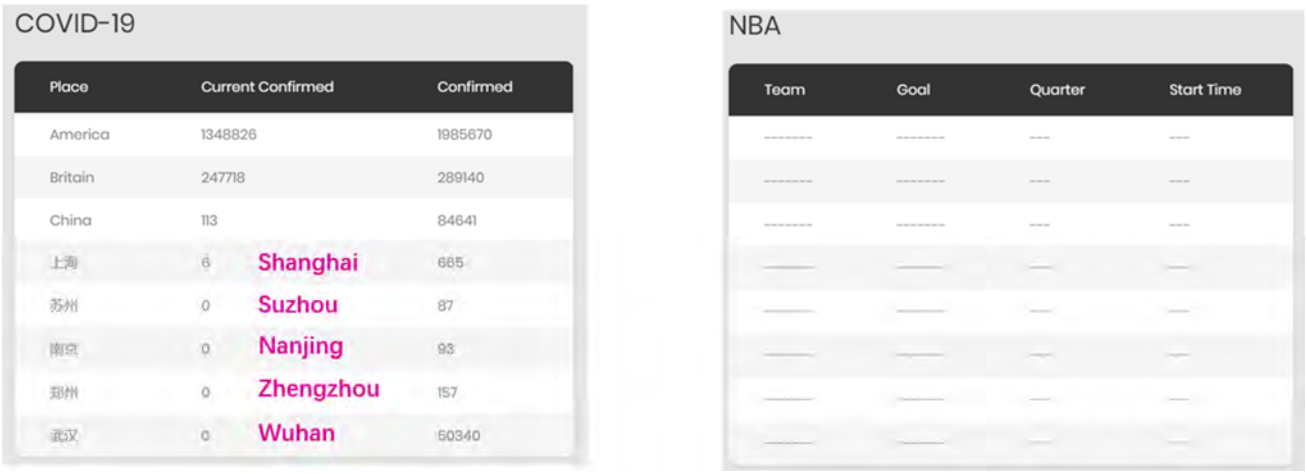


Figure 78: Coronavirus and NBA Program

NBA competition has been canceled, so that there are no relevant records. Both of the two modules can be altered to monitor the relevant information.

4.4.13 Social Affairs Tracking Modules

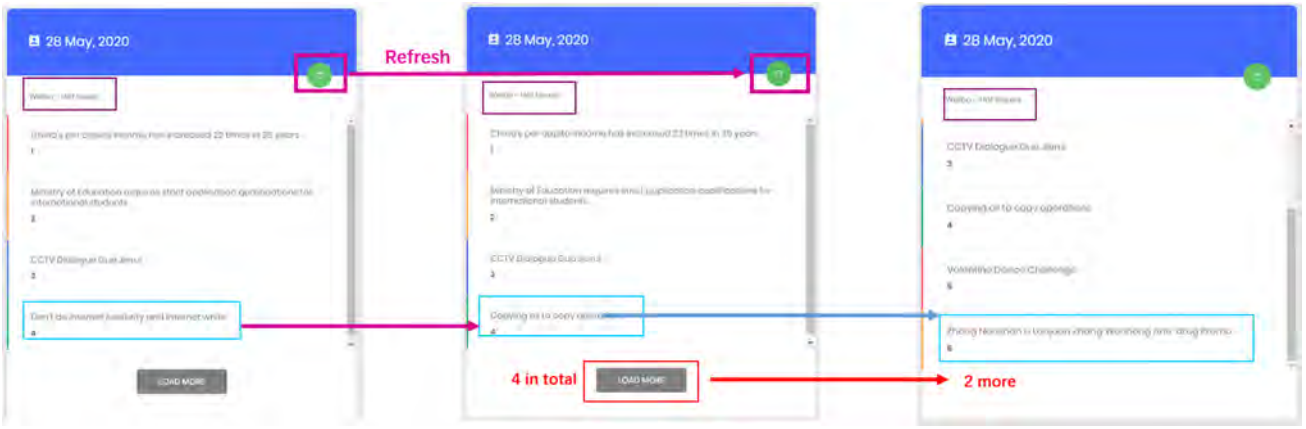


Figure 79 : Weibo Hot Issues

Figure 80: Zhihu Hot Issues

4.4.14 PPG Signal Display Window

Figure 81: PPG Display Window

This window is applied to show PPG signal in real-time through IoT technique.

4.4.15 Health Analysis Result Display Elements

Figure 82: Vessel Assessment Indexes

Figure 83: Heart Rate and SpO2

The instantaneous heart rate can be used for arrhythmia diagnosis, bradycardia and tachycardia can be reflected by average heart rate, to some extend SpO2 can reflect the state of nervous centralis, crest time, RI and SI are applied for reflecting arterial compliance.

4.5 Cloud Server

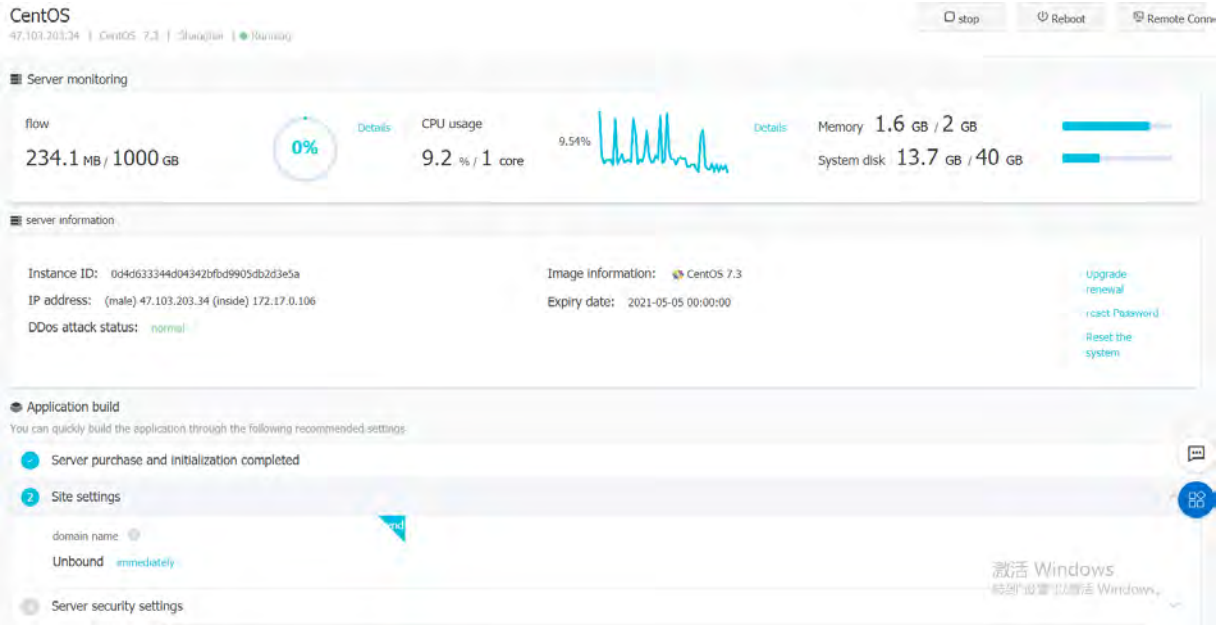


Figure 84: Cloud Server Dashboard

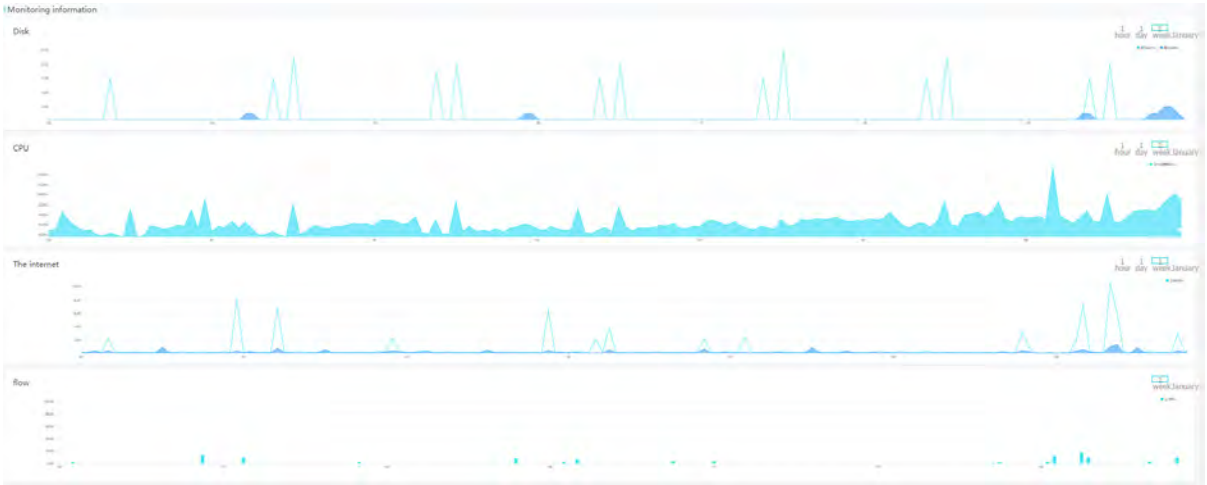


Figure 85: Cloud Server Monitoring Information

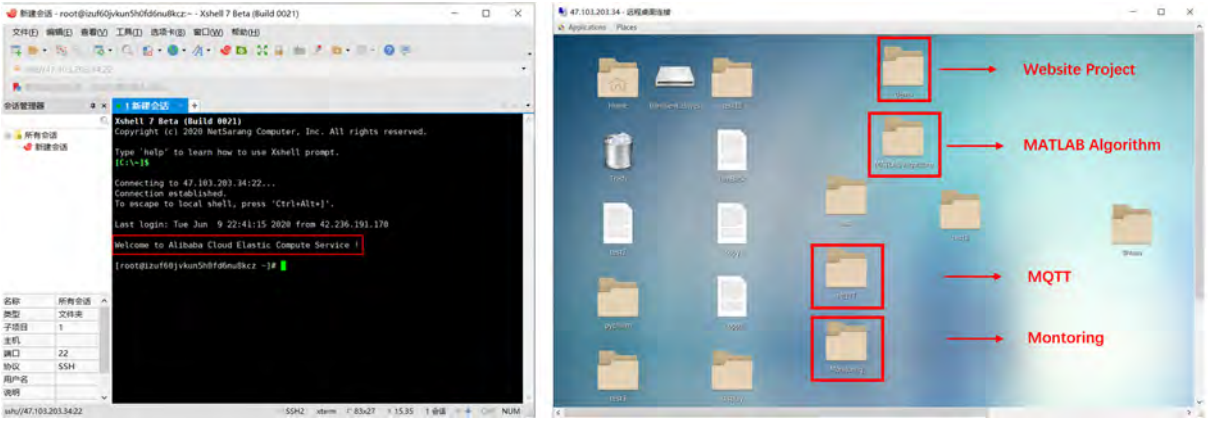


Figure 86: Linux Connection and Visualization Desktop

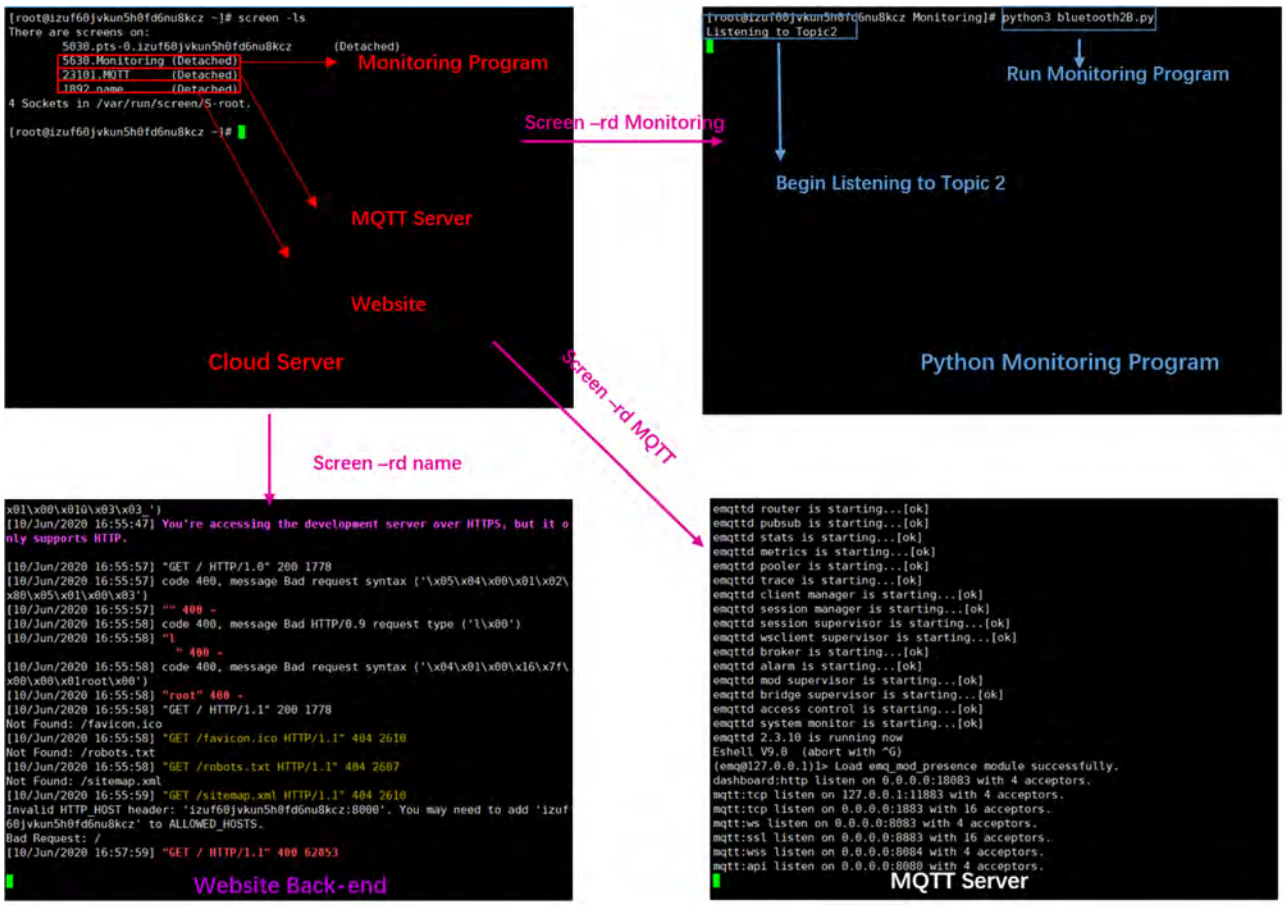
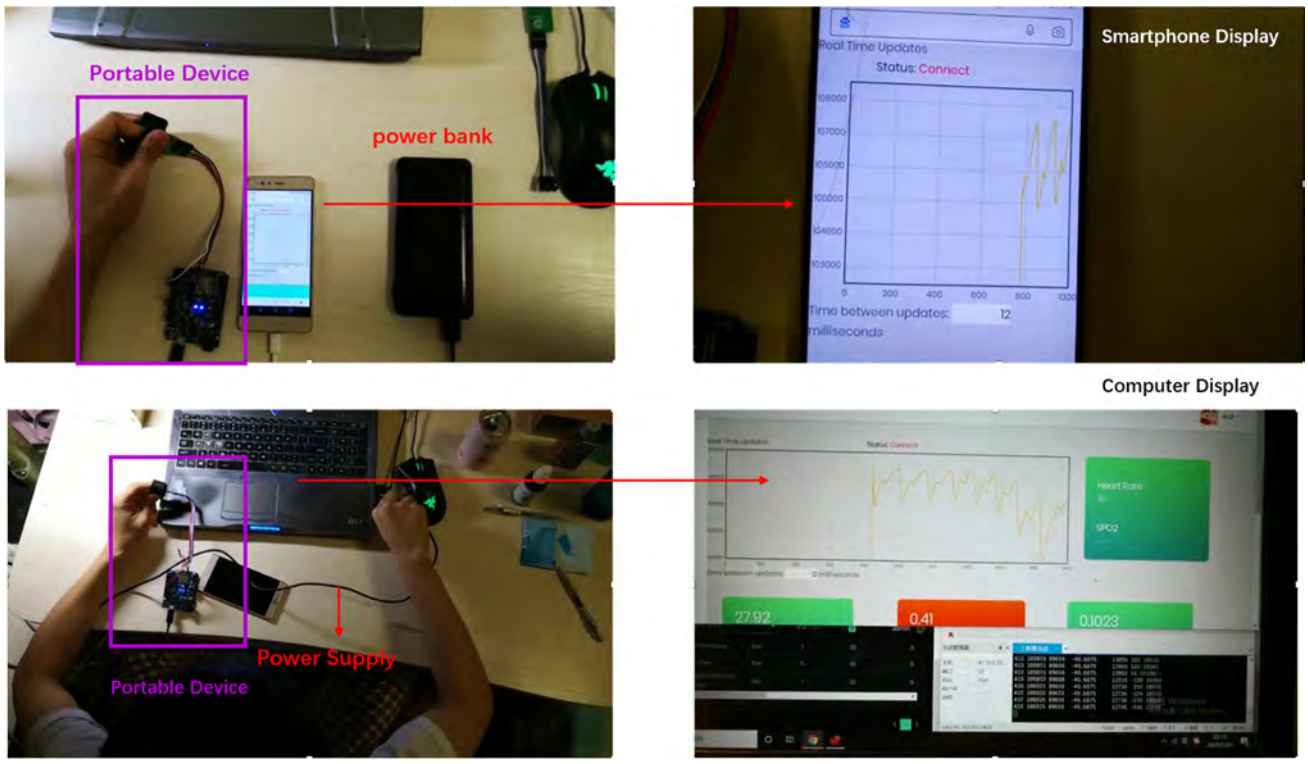


Figure 87: Cloud Server Running Display

4.6 Internet of Things



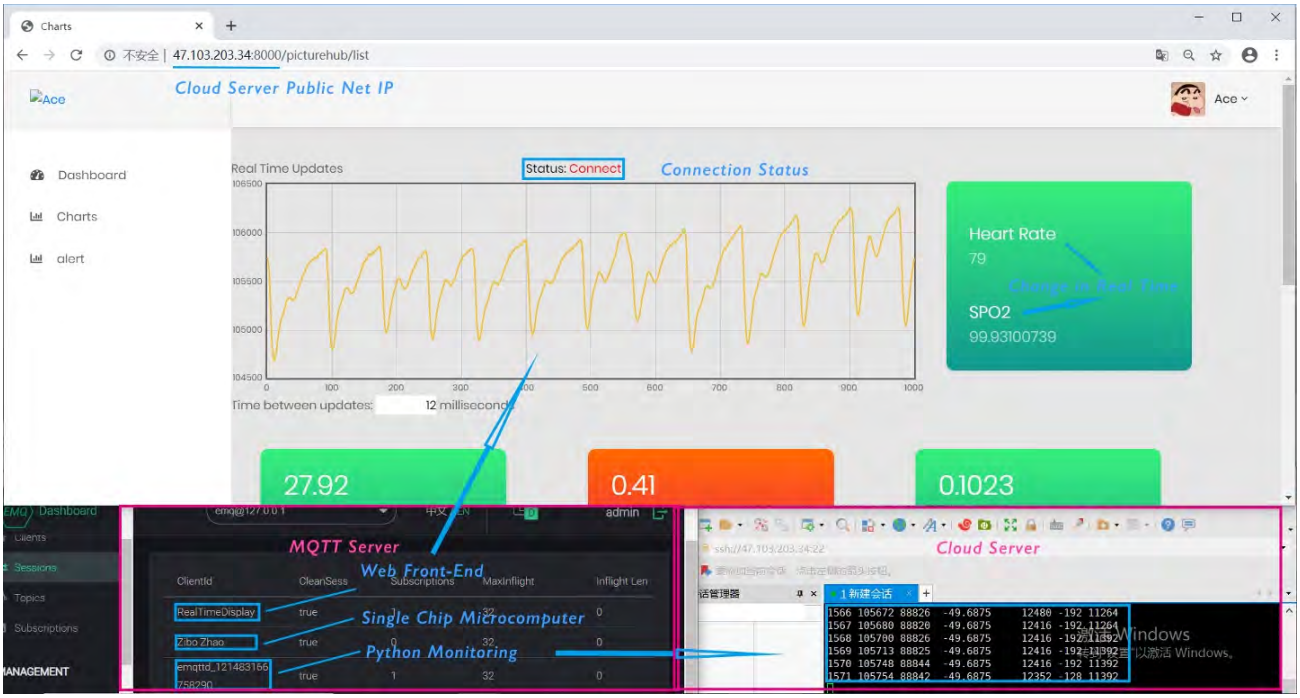


Figure 88: Internet of Thing Technique Display

The IoT part has roughly done, users can user either smart phone or computer to access the subpage and monitoring the PPG signal in real-time. However, this part is not perfect yet, the PPG display time is not exactly same with the sampling time, which may due to the connection delay.

Discussion

On the basis of the research achievements of the first two studies introduced in literature review, this study established three vessel evaluation indexes and implemented the calculation algorithms successfully. Compared with original research, this study acquires more information from the PPG signal and provides smokers with more meaningful information with relatively high accuracy. Meanwhile, to be more practical, this study has also realized a portable device for PPG signal measurement and allow users monitor their physiological signal in real time. Compared with the research conducted by Abdullah H. Alsharif and Nada Philip, this study provides user with more elegant interface and more comprehensive psychological therapy. However, the advantage of combining clinic experience with smartphone application, is not covered by this study. Besides, compared with QuitIT mentioned in literature review session, this study has more functional modules to motivate smokers quit the habit and also introduces the intelligent assistant to make full use of the advantage of automated chat system (indicated by D. Williams et al [9]).

5. Conclusion and Improvements

5.1 Conclusion

In this project, a system was built for smoking cessation and health tracking. The system consists of portable device, health analysis algorithm, website and IoT technique, four main components. Portable device, which is established on the basis of the PPG technique, is applied to measure the body signal and acquire the raw data. Then health analysis algorithm is adopted to generate vessel evaluation indexes, heart rate and blood oxygen level. By applying the IoT technique the PPG signal and the health analysis results can be displayed on the website in real-time. The website provides user a comprehensive psychological therapy (CBT). Besides, it also provides users with a functional personal home page to enhance users' experience and let the website become more competitive (then it can help more smokers). The portable device is designed for smokers and provides more meaningful information than the majority of current portable health analysis devices. Therefore, to some extent, it fill the vacancy of the market. In comparison with the mainstream smoking cessation method, the website provides the psychological therapy to help smokers get rid of the mental addiction, which is meaningful attempt in this field and may ultimately help many smokers quit the habit.

5.2 Future Work

This project involves lots of works, and majority of them were completed successfully. However, there are still some drawbacks in health analysis and website development aspects. In the health analysis aspect, firstly, the current works are down in time domain, and the information hidden in frequency domain is not exploited. Besides, the design of filter is not good enough, for which will cause the distortion of the first 1000 data points. Additionally, the current analysis algorithms are written in MATLAB, which may increase the complexity of the system for the monitoring program is written in Python. Meanwhile, the reliability of the vessel assessment indexes needs to be proved further, when the indexes are applied to evaluate the vessel condition of smokers. In website development aspect, in the first place, the development procedures were not standard enough. For example, some resources were stored in the template file, when they were supposed to be stored in static file (template file and static file are two components of Django Framework. Secondly, the login system is not perfect, for the user has to refresh the page, even though login button has been clicked. Besides, Diary system is not perfect neither, for the diaries will not be stored in the database, which means users cannot close or refresh the page, if they want keep the diaries. Meanwhile, sometimes users have to wait for a relatively long time for loading the resources. Lastly, the website interface for smartphone is not elegant enough.

Improvement	**Methodologies**	**Expected Time**
Frequency domain analysis	Multi-resolution wavelet decomposition, wavelet entropy technique and Genetic algorithm [].	1.5 months
Increased system complexity	1. Rewrite the algorithm with Python. 2. IPC- Build socket connection (OPC Toolbox or UDP)	1- Two weeks 2- Less than one week
Vessel evaluation indexes	Design questionnaire and do experiments	1 month
Development procedures	Rearrange the resources and improve file architecture.	3 days
Login System	1. Set the AJAX to synchronous transmission 2. Face Recognition Login	1- 2 hours 2- 1 week
Diary System	Synchronize the diaries to database	1 day
Long loading time	Transfer the online resources to cloud server	1 day
Smartphone interface	Redesign the smartphone interface	2 week or more

Table 15: Improvement Methodologies

Reference List:

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Appendix A. Important URLs

[1] Internet of Things Implement Development Blog:

https://blog.csdn.net/qq_42141943/article/details/106197337

[2] Linux Operation System Learning Notes:

https://blog.csdn.net/qq_42141943/article/details/106017380
https://blog.csdn.net/qq_42141943/article/details/105983223

[3] Cloud Server Setup and Website Deployment Blog:

https://blog.csdn.net/qq_42141943/article/details/105916765

[4] Social Focus Tracking Module Data Source:

https://s.weibo.com/top/summary?Refer=top_hot&topnav=1&wvr=6
https://www.zhihu.com/hot

[5] GBP Exchange Rate Data Source:

https://srh.bankofchina.com/search/whpj/search_cn.jsp?erectDate=&nothing=&pjname=%E8%8B%B1%E9%95%91&head=head_620.js&bottom=bottom_591.js

[6] Tushare Library Download Address:

https://github.com/waditu/Tushare

[7] Coronavirus Situation Monitoring Module Data Source:

https://ncov.dxy.cn/ncovh5/view/pneumonia?from=timeline

[8] National Basketball Association Data Source:

http://nba.stats.qq.com/schedule/

[9] Login Interface URL:

http://47.103.203.34:8000/

[10] Personal Home Page URL:

http://47.103.203.34:8000/picturehub/index

[11] Smoking Cessation Hub Page URL:

http://47.103.203.34:8000/picturehub/alert

[12] Health Analysis Result Page URL:

http://47.103.203.34:8000/picturehub/list