

An IoT System for Life Habits Monitoring and Feedback Giving on Diet and Exercise

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Abstract

In recent society, people's pursuit of health is accompanied by the fast rhythm of life. Thus, to help people become or stay healthy without causing trouble to them, a comprehensive health system for monitoring users' basic life habits and giving feedback without intersection with users' life should be designed. In this work, an IoT system in health field is designed, which consists of smart devices that are commonly seen in our present daily life, a cloud that can process data from all devices and give feedbacks. The system get data from the user's diet, exercise and sleep condition respectively through different devices and give feedbacks under the condition of considering the relationship influence among that three aspects. All the devices are commonly used in daily life, so that the trouble of buying new things or uploading data by users themselves are avoided. The boundaries between different aspects of daily life are broken because the system can make consider the user's body health as a whole, which is very creative and inspiring.

Keywords

IoT system; Health suggestion; Diet; Exercise; Location.

1. Introduction

The diseases caused by bad life habits, like obesity, hypertension and diabetes can be effectively controlled by the change of life habits, it can even be completely prevented if people follow a proper way of life from the beginning, such as spending less time sitting and a balanced diet. [1] Now, people can easily access their healthy index such as glucose, blood lipids, blood pressure and so on. Also, people can learn all kinds of information of the general healthcare knowledge, but it is not easy for letting them spend their time learning and monitoring all sorts of healthy information. It is too difficult for people to use this information effectively as well. So, it is necessary to develop a health management system to monitor and analyze user's daily behavior in order to give healthy information and spend less of the user's energy on the health issue.

In earlier researches, there are many diet and exercise management systems, however, the operation of the most previous healthy applications depends on the upload of the user, which may cause fraudulent information and troubles to user. Also, most systems only focus only on diet or exercise, while it is known for all of us that diet and exercise can affect each other. Moreover, recent health applications are kind of like partially prepared products. After providing suggestions, the user still needs to make effort finding a way to realize it. Our system can tell the user where to go so that they can buy required food and do sports. The system can also combine user's preference. This is the IoT System for Health-Monitoring and Advice-Offering on health based on diet, exercise.

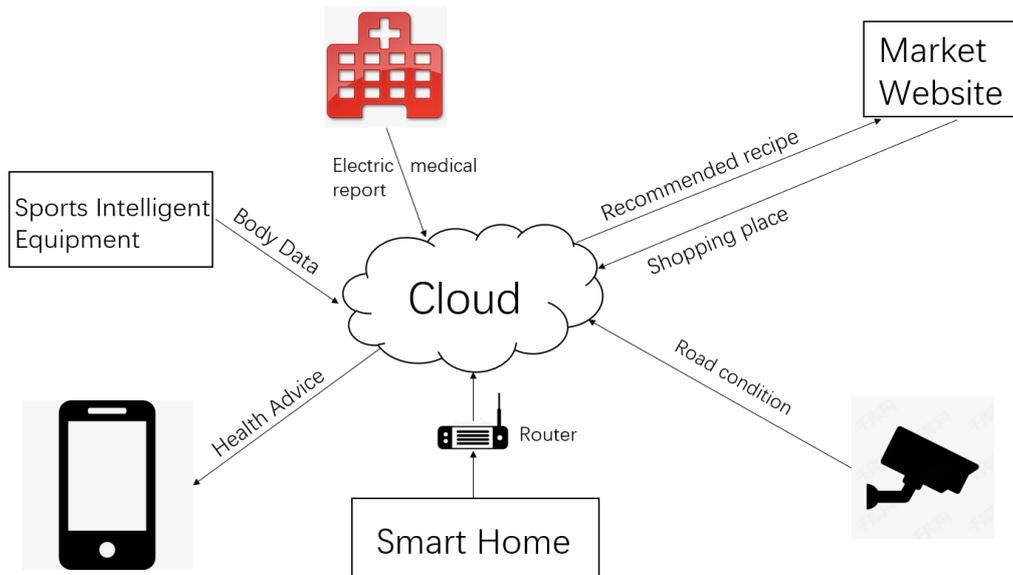


Figure 1: System Structure

2. Basic structure of the system

As shown in Figure 1, the system has a cloud terminal for algorithmic operations. The cloud can process the data collected by all kinds of devices, get access to the GPS system, market system, hospital electronic records, make suggestions for daily life based on the user's daily life's data, preference and Internet information. Devices in diet home and sports intelligent equipment are responsible for collecting the user's diet and exercise habits and information, such as what they eat, how much time do they exercise. The surveillance camera is well-developed, road condition can be detected, all the information of the commodity will be uploaded by the market to the Internet, the system can make use of these information.

3. Functionalities

3.1 Diet planning

The first module is diet planning. Diet is an important part of human's body and it can affect lot of other aspects of human's body, liking sleeping. This module is able to monitor the change of the user's basic information, figure out what nutrients the user needs to take in and give the user a healthy recipe. For example, if the user's blood pressure, which is monitored, in the database rises, the recipe that is given back to the user will modulate the fat, salt income and recommend more food that contains calcium and vitamin because calcium and vitamin are long thought to be good for patient with high blood pressure. If the user's blood glucose rises beyond normal, the server in the cloud is able to detect that the user's unhealthy body.^[2] To make this function come true, the user's health indicators needed to be collected. The devices that are able to collect information are described in the next chapter.

As shown in the figure 2, the database contains a basic standard and the information collected by devices will be compared to the standard information to figure out if there are any dangerous signs. After the evaluation, a health report will be given. When giving recommend recipe, this report will be the most significant factor. This module faces to every single user, so the recipe has to be individual. Thus, the food storage and the user's dietary preference will be also considered. These three sectors are of different importance.

The user's exercise information also needed to be taken account. Calorie matters. If the exercise information in the database shows that the user burns too much calories, the food the user takes in should also change to match the calory consumption.

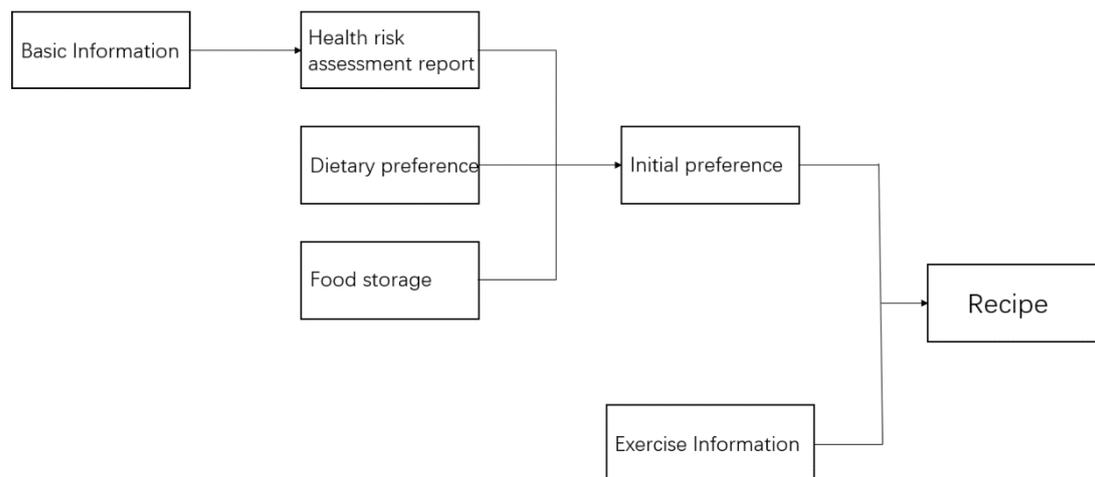


Figure 2. Diet Planning -Process Diagram

3.2 Exercise planning

As people get older, more and more time is spent on sitting in front of the desk or computer, this may cause diseases like cervical spondylopathy and the cardiopulmonary function will be decreased. Moreover, the older the person, the greater the impact of sedentary time on cardiovascular [3]. However, it is difficult for people to make use of their leisure time determine the best way to exercise and put the exercise plan into effect. The feedback and sports plan giving module are built up to solve these problems.

The exercise plan given by this module is based on three parts. The first part is user's conditions, for example, BMI and sex. The second part is the user's sedentary time. The third part is the motion data monitored by devices like the restriction rate of muscle and the time of running. In making suggestions, the first part is the base and essential. Making individual suggestions need to know the body condition of individual. With the second part, this module is able to give out the best way to reduce the harm caused by sitting for too much time. This module is a feedback system, thus the suggestion given needs to be based on the effect and the user's preference. Preference will be analyzed online based on the data collected by the devices mentioned in part three.

Exercise and diet can interact on each other, which means that when considering exercise plan, the user's diet condition also needs to be thought of. For example, the proportion of aerobic and anaerobic exercise is partly decided by the proportion of fat and protein in the user's diet. This data collected by diet part will be stored in the database.

3.3 Shopping and sports place recommendation

Considering that the goal of this system is to help people become or stay health and reduce the amount of energy that people spend on their health, minimize user participation and free users from tedious search process, the system still needs to have a module which can recommend shopping and sports place. When giving suggestions to the user, this module can inform the user of the best market to go to, where the distance from the user's house and the price will be optimized, and suitable sports place, so that the user can do sports without being limited to their own house. With this module, the system can not only tell the user what food to eat, what sports, but also tell the user where to meet the requirements.

The system will have the access to all the shops' information and the urban terrain technology. With the technology of barcode, the information of every food is contained in a single chip, and the information can be sent to the Internet. With the help of Internet and code scanning technology, the health system can compare the prices of food, which is needed in the giving recipe, in different shops where near the user's home and provide the best place to go to. For example, in the recipe the system

gives it to the user, eggs are needed so lots of eggs need to be bought by the user. Without the system, the user needs to think about which shop to go to by themselves. They may miss the discount as well. With this module of the system, the system can tell the user which shop is worth going to after providing the recipe. So, the user can save their time and money, get the required food as well. When giving sports plan, the system can get access to the GPS and make use of every information inside. For example, when running is recommended in the plan, the system can use GPS to find the best place, like asphalt road and tell the user to run there.

4. Data

4.1 Basic information

4.1.1 Height & Weight

BMI needs the data of height and weight. The BMI can determine the fat rate of the user ^[4]. All the users need to be divided based on their BMI, so that the suitable food and exercise with different nutrients and moves can be given.

The devices that collect the information of height and weight can be a smart mat. The smart mat can embed a weight sensor. This mat can be put in front of the door. Whenever the user goes inside or outside the door, they must step on the mat so that the weight can be measured. A smart mirror is needed to place inside the bathroom. The smart mirror can embed an MCU. Whenever the user stands inside the bathroom to brush teeth, the mirror can know the user's height with an infrared. The data collected by the infrared will be processed by the MCU and stored.

The height and weight of an adult hardly changes, so the smart devices can be put at home permanently. To increase the reality of sending data, the devices should be connected to the Internet through WIFI, not Bluetooth, which needs a phone to be a gateway.

4.1.2 Age & Sex

Our system is oriented people in different ages and sex, all the plan given needs to be based on this information. So, the information is vital. An application is designed for the user to update this information on the phone. Moreover, this information will only be uploaded for one time, so little trouble will be brought to the user.

These data can be sent to the Internet by the cellphone easily.

4.1.3 Electronic Medical Record

It is commonly seen that hospital's doctor will upload the electronic medical record to the Internet, the system can obtain this information by having connection with medical institutions. The medical record includes the result of the user's comprehensive physical examination and past medical history.

4.1.4 Blood routine, Urine routine & Stool routine

These data of the user play a vital role in evaluating the user's health, including the user's blood pressure and blood glucose. The device for measuring blood routine is the blood test instrument located at home and there is a smart toilet in the bathroom. The smart toilet can collect part of the user's urine and excretion and analyze it to get the routine data of urine and stool.

Since these devices are located at home, so these devices transmit the information to the database through Wi-Fi.

4.1.5 Blood Pressure, Blood Glucose & Heart Rate

The user needs to wear a smartwatch which can monitor the user's blood pressure ^[5], blood glucose and heart rate.

The smart watch can get access to the Internet easily, so data collected by the smart watch can be transmitted to the database through Wi-Fi.

4.2 Dietary Data

4.2.1 Food storage

The goal of our system is to keep the user staying healthy without causing too much troubles on the user, so when giving suggestions, the recipe needs to be practical. Thus, it is vital to get to know the information of the food storage in the user's house.

Due to the advance of IoT technology, each food is accompanied by a special bar code, which stores information about the source, type, production date and shelf life of the food. Also, the kitchen will be equipped with a smart refrigerator, or a smart box. The smart box has bar code scanner, weight sensor and camera. The scanner inside can scan the bar code on the food, with a weight sensor, the smart box is able to monitor the weight and the changes of the food. The camera is used to identify the type of the food. Whenever there are changes in the box, these sensors are able to monitor that, including the type of food, how much food is inside the box.

All the information is collected inside the user's house, so the smart box can be connected to the database through WIFI.

4.2.2 Dietary Preferences

The dietary recipe needs to be personal, so catering to the user's preference is very important. The preference will be uploaded by the user through the application on the phone. The database will receive the information and make suggestion based on the user's preference. Additionally, the preference can be changed in real-time.

The cellphone is the device used to collect the preference information, so, this information can be transmitted to the database easily through cellular network.

4.3 Exercise Data

4.3.1 Motion

Exercise needs to be moderate, excessive exercise may cause joint pain or muscle pain. It will not only affect the exercise result but also cause irreversible effect to the human body. Thus, in this system, while the user is doing exercise, some data that can show the body function needs to be collected in real time, so that the system is able to know whether the plan is within the user's tolerance. A personalized, feedback suggestion must not be static.

The most apparent data that can show the user's exercise load is heartrate. While when exercising, wearing a smart watch is uncomfortable. Thus, in this system, a new way to determine the exercise load based on heart rate is used. Based on the TRIMP theory, the user wearing a smart vest that embed with GPSPORTS equipment, including heart rate band, is able to exercise without the trouble caused by clothing and the heart rate can be updated and processed in the cloud, using the TRIMP calculating way. The smart vest can also function in collecting data of aerobic exercise. The smart vest is capable of recognizing user's behavior and detecting joint injury. The IMU chip can finish action recognition^[6], which is a small and easy chip based on MEMS. The MMG^[7] sensors can test the muscle contraction and friction of joint. For example, lower limbs down to the ground fast and the upper limbs rotate rapidly around the fulcrum is always seen in track and field. This motion is also always the cause of sports injury.^[8] Thus, the effect of this motion needs to be monitored in real time to avoid injury. Thus, the action recognition and the detect of muscle and joint is necessary.

The sensors inside the smart vest needs to be small and light, so the communication chip is very important. Bluetooth is used to transmit all the data. The sensors and phone are connected by Bluetooth. After the data is sent to the cellphone, the cellphone sends the data to the database.

4.3.2 Sedentary Time

For most of the users, where they stay the most often is either at home or at office. Thus, for calculating the sedentary time, recording the time at home and office is indispensable. One of the goals of the sport suggestion giving is to offset the bad effects caused by sitting for too much time. So, the sedentary time data is needed to decide the amount of the exercise^[9]. For example, if one sits

on the chair for too much time, the stress point and sitting time will be sent to the database by devices. The device can be a pressure gauge inside the chair. The sitting data contains the pressure point and time, so that the database can figure out the sitting pose and calculate the effect. Then, in the next exercise plan, some exercise will be included in specific to compensate for sitting in specific gesture. All the device must be light, small, flexible and embed to daily life furniture. Only in this way can the user expose their sitting habits in real life, and the system can apply medicine according to indications.

When people work in office, people always work with computer, so the camera inside the computer can be used to decide the sitting time and recognize sitting pose. The database can make sports plan according to the user’s sitting posture.

4.4 Information for shopping & sports place recommendation

4.4.1 Market place and commodity price

When considering which shop to go to, the two most important factors are distance and price. Especially for old people, they would like to spend a lot of time searching for the cheapest commodity price, which is very troublesome and exhausting. Under this circumstance, our system aims to solve the problem of spending time searching for a market with the lowest commodity price. This needs to be done by a specially designed program.

Figure 7 shows how the information of the commodity is uploaded. The first part of this system is barcode scanning system. The device responsible for scanning the code is a webcam installed on Raspberry Pi. The photo of the bar code will be processed there [10].

After the barcode is recorded and processed, the information needs to be uploaded to the website. The barcode scanning module is controlled by STM32 processor, the module can automatically run and upload the information to the website in real-time.

The database of the shopping website is also very important. Considering the freshness of the ingredients and the accuracy of the information, the information of the commodities in the website needs to be refreshed once a week. The information inside the website needs to be classified into different shops, prices and types of food.

Compared to Zigbee and Bluetooth, the WIFI can access to the Internet easily, has a better mobility and transmitting speed, this characteristic can match up with the environment of the market. So, with an ESP8266 chip connecting with the STM32, the information collected by the Raspberry Pi can be uploaded to the system database through WIFI.

Figure 8 shows how the recommendation is given. Information about all goods in different shops and recommended food are considered.

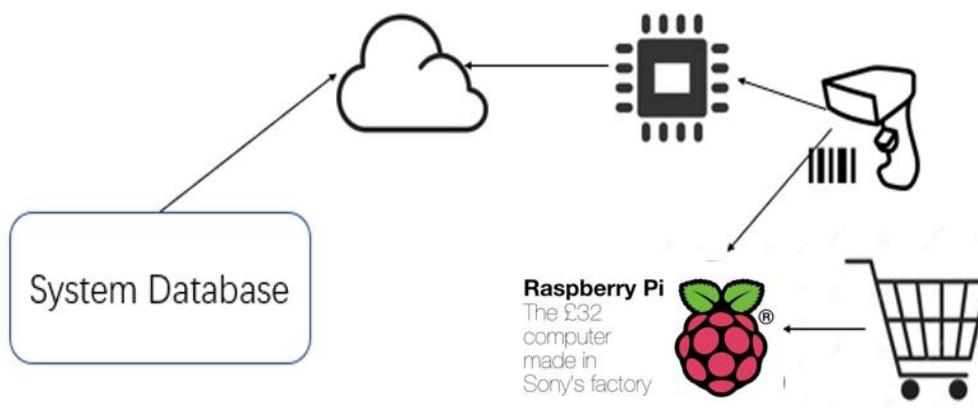


Figure 3. Supermarket information upload map

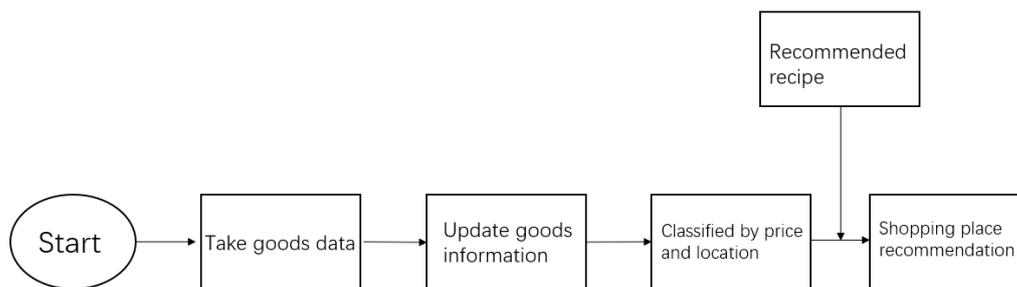


Figure 4. Shopping place recommendation map

4.4.2 Sports place

The aim of this module is to shorten the time people searching the proper place to realize the suggestions on diet and exercise. Thus, except for informing the user of the best shop to go to, the system needs to also list the proper place for exercising. When swimming is listed in the given plan, without the sports place recommendation module, the user still needs to find the nearest swimming pool and ask for the price, which can waste a lot of time. When running is listed, the user may run on cement floor, which can cause harm to user’s joints. With this function, for example, when the system tells the user to run, the system will also find the nearest asphalt road or exclusive running road, so that the user’s time can be saved and the best place for exercising is provided.

In order to figure out the best place for outside sports, the most important information is the material of the road. Different material can have different mechanical properties, and have influence on people. To get to know the material of the road, the smart device, which is a surveillance camera is needed. The technology used for material recognition is deep thermal imaging [11]. All the surveillance cameras are put near the road, with a camera which can realize deep thermal imaging, The surveillance camera can embed with an MCU, which can do deep learning of spatial surface temperature pattern. Through this process, the material of the road can be recognized. To upload the information to the Internet, WIFI stations need to be set. So that the result of thermal recognition can be transmitted to the Internet through wireless communication chip embed inside the surveillance camera.

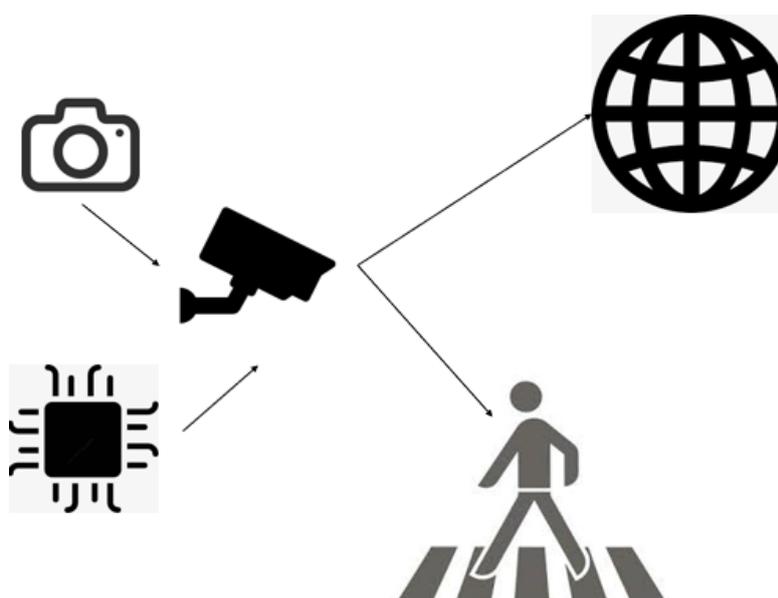


Figure 5. Road material upload map

5. Conclusion

The system is designed to monitor the user’s daily life without causing influence to people’s daily life, make people stay healthy and stay away from bad habits.

This system integrates the technology of sensor and wireless communication, build up a device Internet. Thus, this system is able to monitor the user's body condition, like blood glucose, heart rate, etc. and user's daily habit including dietary preference and exercise amount in daily life without causing influence on user's daily life, no matter the user is at home, office or outside. All the devices are connected with the database in the cloud. The data is collected and analyzed in the database. In suggestion making, all the data is accessible and considered in hierarchy, the diet and exercise suggestion are moderate and personal. The suggestion is made to make people stay healthy.

The system also absorbs the technology of bar scanning technology, successfully transfers the entity information to the Internet. Through this function, the system can recommend the best shop and the most suitable place for the user to do exercise. The realization of this module means that the user can follow our suggestions easily, without spending time searching all kinds of information.

Besides the practicality of the system, it is meaningful for future research as well. Mix different aspects of health together and give out a comprehensive health suggestion is a great idea and direction for future direction. With the set up of this system's cloud processor, any aspect of health can be put in without damaging the origin structure. When the technology develops further, the monitoring system can integrate with the ambient environment recognize everyone in the view, record everyone's life habit and analyze their bad life habits.

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