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Building of Smart Home Medical System Based on Internet of Things

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Abstract: Based on Internet of Things, Smart Home Medical System receives health data through the terminal electronic medical equipment, making the whole system an implementation. The System is divided into four layers, namely, Perception, Network, Platform and Application. It realizes the intelligence and automation of home medical system by means of detecting, diagnosis, forecast and consultation. The building of Smart Home Medical System can be comprehensively displayed through the system requirements, system design and system implementation.

Keywords: Internet of Things, Smart Home Medical System, Data

1. Introduction

Internet of Things, artificial intelligence and other technologies are widely used with the development of information technology, thanks to which Smart City come into being and got widespread social attention. Applications based on Smart City develop continuously, playing a significant role in urban development. They accelerate the pace of urban construction, solve the problem of urban development, and provide a strong support for the efficient and orderly operation of city. Meanwhile, Smart City services are becoming a norm. [1, 2, 3] Smart City can make intelligent response to different kinds of needs, including daily livelihood, environmental protection, public safety and city services, industrial and commercial activities. [4]

Health care [5] is an important part of Smart City. Research and application of Smart Home Medical System has received extensive interest from society, exerting a positive effect to the promotion of healthy development of cities and the construction of a harmonious society. Smart Home Medical System can greatly alleviate the current unavailability and high cost of medical treatment. People can have medical examination, diagnosis, medication and other procedures through electronic medical equipment at home, accessing the relevant medical services easily. Therefore, Smart Home Medical System is not only the development of information technology, but also progresses the medical field.

2. System Requirements

The Internet of Things (IoT) is a network of internet-enabled objects together with web based services that interact with these objects. [6]

The areas of IoT personal health sensor and software development [7] is one of the most active areas of the IoT ecosystem and Public health interventions [8] and are a key component of future Health Participatory Sensing Networks (HPSNs) [9]. So the Internet of Things will play an important role in the field of the future health. Being more convenient, many expert systems will be designed to diagnose and treatment of disease [10].

Based on Internet of Things, a Smart Home Medical System gets health data through the interrogation of the terminal unit of Internet of Things. Through network transmitting, the data can be used in the application layer.

Smart Home Medical Systems mainly include health detecting, disease diagnosis, disease risk prediction, doctor consultation and so on.

Health detection includes test of blood glucose, blood pressure, lipids, heart rate and other health data. Various indicators can be tested and data are uploaded, with personal

data stored in one's health profiles, providing data support for the implementation of diagnosis and other medical measures in the future.

Disease risk forecast includes common disease diagnosis. The disease diagnosis system is mainly in accordance with personal health data collected in health detection and corresponding expert system.

Through personal health data and related scientific algorithms, disease risk forecast can make assessment of the disease risk of the user and provide users with scientific methods to reduce the risk of illness.

Doctor consultation allows users to easily inquire about their medical information according to their needs. Through the offered information of hospitals, doctors, symptoms, drugs and disease, we can meet the inquiry needs of the users. At the same time, doctor consultation provides users with text, voice, video, and other online means to consult the doctors so that users can get quick and effective answers of their medical problems.

The main functions of Smart Home Medical System are as mentioned above. Each function of the system is an important component to make the intelligent, convenient and efficient medical service a reality.

3. System Design

3.1. Model Design

According to the framework of Smart City, Smart Home Medical System is divided into four layers, namely, Perception, Network, Platform and Application,

Perception is the most important part of the Smart Home Medical System, which mainly detects blood glucose, blood pressure, lipids, heart rate and other health data through the use of simple medical electronic sensing devices.. The detected data is transmitted to the receiving device (such as PAD, smart phones, etc.) via the sensor network, which can be achieved by ZigBee, Wi-Fi, bluetooth and so on. The access devices are usually devices that can receive wireless data (such as PAD and smart phones).

The concrete model of Perception is shown in Figure 1:

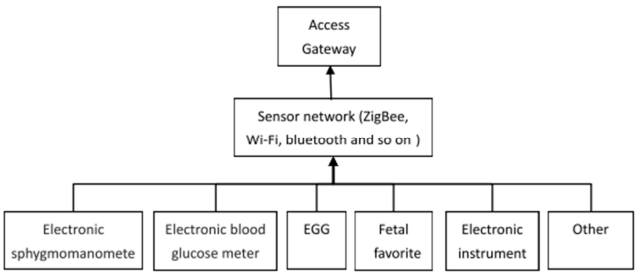

Figure 1. *Model of Perception.*

The Smart Home Medical System not only selects the desired sensor devices in the Perception layer, but also selects the appropriate communication network or triple-play in Network. It also needs an Expert System in the Platform layer and the corresponding Smart Home medical applications in the Application layer.

The major model is shown in Figure 2:

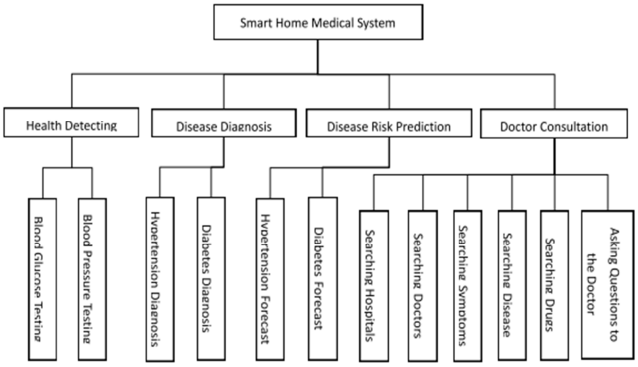

Figure 2. *Functions of Smart Home Medical System.*

3.2. Function Design

Smart Home Medical System is divided into four sub-systems, namely, health detecting system, disease diagnosis system, disease risk forecast system and the doctor consultation system. Among them, the health detection system includes blood glucose testing, blood pressure testing and other routine data detection. The disease diagnosis system includes diagnosis of common diseases such as hypertension and diabetes. The disease risk prediction system can forecast the prevalence of hypertension, diabetes and other common diseases. The Doctor consultation system includes functions of searching hospitals, doctors, symptoms, disease, drugs, consulting the doctor and so on.

A systematic-functional framework of Smart Home Medical System is shown in Figure 3:

When users log in to the system, they can select which system to use for their desired service.

After choosing health detection, the system will automatically retrieve user's information, allowing users to select the testing items. Once selected, devices will be connected, and the detection begins. After the test, the data will be uploaded to prepare for the users' control and inquiry.

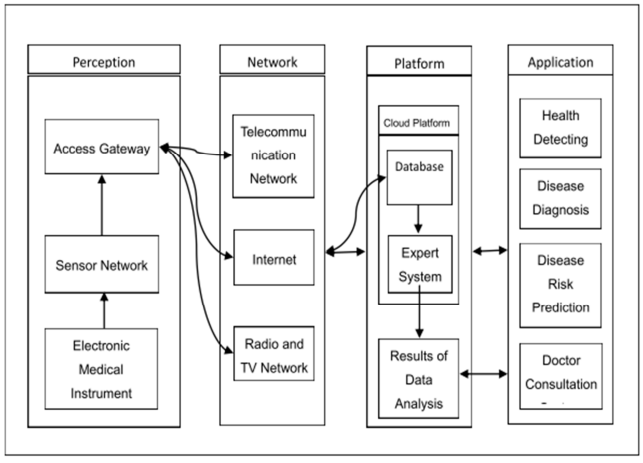

Figure 3. *Model of Smart Home Medical System.*

After choosing the disease risk forecast, the system will automatically detect the user's data. If the user's data are incomplete or need to be modified, the users need to improve the data according to the prompts, and then, forecast the risk of illness.

After choosing intelligent diagnosis, the system will determine whether the user's data meets the diagnosis requirements, if they do meet, the diagnosis will begin, otherwise, the user will be asked to operate according to prompts.

After choosing Doctor consultation, the user can choose self-service or manual service. Upon self-service, the user can operate the system and obtain the result. Upon manual service, the user can consult a Doctor via text, language, pictures and other information, and obtain the reply from the doctor.

3.3. Data Collection Function

Health detection mainly uses electronic devices to detect the health data of user, and uploads data to the access gateway by the sensing network. So the detected data can be passed to the server through the network, and then stored and analyzed intelligently. The system can achieve the purpose of the data detection, data accumulation, and intelligent data analysis.

The detection of blood pressure can be cited as an example.

First of all, the blood pressure meter should be connected to the intelligent terminal via Bluetooth protocol, which is realized by mac addressing. Once connected, Socket pipe connection will be established. Secondly, the blood pressure meter sends the detection results to the intelligent terminal; the results are then included in the data protocol of the blood pressure detecting device; the intelligent terminal receives and parses the data protocol, obtains the results, and checks them. Finally, the health data will be uploaded onto the server by the access gateway, and stored in the database.

Electronic instruments send the detection results to the intelligent terminal. The implementation model is shown in Figure 4:

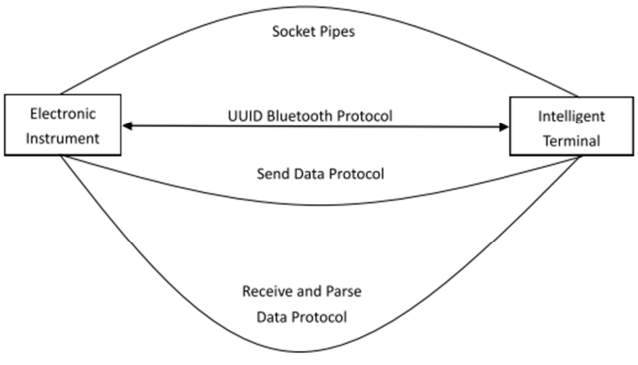

Figure 4. *Data transmission.*

3.4. Algorithm Design

The Smart Home Medical System function implementation requires a few algorithms to support it. However in this paper we do not to introduce all , but give an example. Here we show how we predict the user's future blood pressure to determine the blood pressure change trend.

ARMA model called autoregressive moving average model, by definition, AR + MA model is a hybrid model, which is defined as follows:

$$y_t=\varphi_1 y_{t-1}+\varphi_2 y_{t-2}+\ldots+\varphi_p y_{t-p}+\varepsilon_t+\theta_1\varepsilon_{t-1}+\theta_2\varepsilon_{t-2}+\ldots+\theta_q\varepsilon_{t-q}$$

When q = 0, ARMA (p, q) model degenerates to AR (p) model; when p = 0 Shi, ARMA (p, q) model degenerates to MA (q) model, so the AR (p) model and MA (q) model is a special case of ARMA (p, q) model. ARMA model using time series forecasting in general need to go through the following steps:

step 1: pretreatment

step 2: Given Order

step 3: Parameter Estimation

step 4: Modeling Estimation

3.4.1. Pretreatment

Before modeling there is a need to check whether the sequence is a smooth sequence, the more common method is to use ADF test (ie unit root test).

For example: the value of a user's systolic blood pressure in the table below.

Table 1. *The Value of A User's Systolic Blood Pressure.*

Days	Systolic blood pressure	Days	Systolic blood pressure
1	145	17	135
2	144	18	133
3	143	19	133
4	143	20	132
5	144	21	130
6	142	22	130
7	142	23	128
8	143	24	127
9	140	25	125
10	138	26	126
11	140	27	126
12	139	28	125
13	139	29	124
14	138	30	122
15	136		
16	135		

3.4.2. Given Order

As used herein, we use the BIC criterion to decide the order, select the p, q ceiling, where take 5 (generally take the N / 10 or lnN values), the results shown in the following table:

Table 2. *The Results of The BIC.*

p	q	BIC	p	q	BIC	p	q	BIC
1	1	103.28	3	1	110.69	5	1	114.2
1	2	104.86	3	2	110.35	5	2	112.72
1	3	109.6	3	3	101.4	5	3	112.51
1	4	114.19	3	4	115.43	5	4	116.07
1	5	115.23	3	5	114.06	5	5	117.75
2	1	103.87	4	1	109.73			
2	2	99.78	4	2	113.04			
2	3	111.07	4	3	116.52			
2	4	107.21	4	4	118.54			
2	5	118.62	4	5	111.44			

As per the table, p = 2 and q = 2 time value BIC were the minimum, so the use of ARMA (2,2) modeling is appropriate.

3.4.3. Parameter Estimation

The ARMA model parameter estimation of a variety of methods, such as solution YW equations, least squares fit, maximum likelihood estimation etc. Here we use a least squares fit method, combined with the use of forward - backward algorithm to estimate, that if used the ARMA model could be represented by the formula:

A(z)y(t) = C(z)e(t)

A(z) = 1 - 1.845 z^-1 + 0.8459 z^-2

C(z) = 1 - 1.805 z^-1 + 0.822 z^-2

3.4.4. Modeling Estimation

Use ARMA (2,2) modeling and verification of the original sequence to fit the results as shown below:

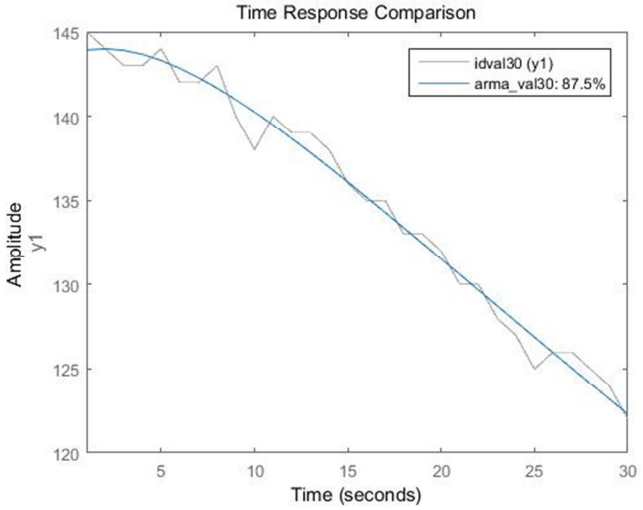

Figure 5. *Fitting verification.*

In Figure 5, the gray curve of the original sequence is shown. The blue curve is the ARMA (2,2) model that is used to draw a curve. It is clear that this is a better fit with the original sequence.

Using ARMA (2,2) of the original sequence 3-step prediction, the result is

Day 31 121.4

Day 32 120.5

Day 33 119.6

4. System Implementations

The collection and transmission of health data are the key parts of Smart Home Medical System, including transmitting the collected data into the database automatically.

Terminal devices in health detecting can establish communication with the system through a variety of ways. Take Bluetooth as example, the code of detecting and connecting Bluetooth device is as follows:

```
/* discover Bluetooth device */
private void doDiscovery() {
        ……
        mBluetoothAdapter.startDiscovery();
        Log.i("WhiteList_Activity", " search ");
        ……
    }

/*connect Bluetooth device */
    public void connectBluetoothDevice(WhiteListActivity activity) {
        ……

    handler.obtainMessage(R.id.executeConnectTask).sendToTarget();
        ……
    }
```

After Bluetooth is paired, data is sent to the terminal program through the optical pipes, the code is as follows:

```
public void sendBroadcast(BluetoothBaseDataParser baseDataParser, int checkType) {
        ……
            savaBloodPressureData(baseDataParser);
        ……
        sendBroadcast(intent);
        ……
    }
```

5. Conclusion

The Smart Home Medical System obtains users' health data through the terminal electronic medical equipment, then the data will be passed to the database automatically, and realize system applications based on Internet of Things. Smart Home Medical System which can realize intelligent, automatic and convenient medical service functions by the organic combination of Perception, Network, Platform and Application. Smart Home Medical System can provide all-round service with integration of detection, diagnosis, prediction and consulting, providing users with medical services that are convenient to use, thus promoting the development of medical career.

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