Design of a NB-IoT-based wearable monitoring system

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Abstract. Designed a wearable guardian system based on NB-IoT （Narrow Band Internet of Things）.To achieve continuous collection of physiological indicators of users such as blood pressure, body temperature, ECG, heart rate, exercise and sleep by wearing a wearable device.The collected data is transmitted to the service center through NB-IoT.The service center monitors the data and found the early symptoms of the disease.When the physiological index exceeds the warning value,immediately offering medical assistance. Realized the monitoring of vital signs of elderly people and chronically ill patients,and achieved the purpose of preventing and monitoring potential diseases and chronic diseases.

Key words: Wearable Device; Narrow Band Internet of Things; Monitoring; Sensor

1 Introduction

With the rapid development [1] of a new generation of technology such as cloud server, big data, embedded system and wireless sensor, wearable devices have played an important role in the field of health care, which can provide real-time monitoring of health status for the elderly and patients with chronic diseases, through the acquisition of vital signs, and can alarm for emergency, to provide timely rescue for sudden symptoms and effectively reduce the harm caused by major diseases.With the rapid development of interconnection of things, more and more intelligent devices are connected to each other, as a result of which, NB-IoT (Narrow Band Internet of Things) came into being, with the support of good communication network, and the wide development prospect ,which has got the attention of domestic and international industry.

Based on the above, a NB-IoT-based wearable monitoring system is designed to collect the users' health data, and transmit the data to the server through NB-IoT. The user or guardians can check the physiological parameters at any time through the mobile client, and the medical staff can also check the health data of patients in the monitoring center, and provide prevention measures and treatment recommendations according to the clinical diagnosis. The service center carries out analysis and processing of the data. When there is an exception, it alerts the medical rescue center to start the timely assistance service. On the one hand, the system realizes the real-time and continuous monitoring of the vital signs of the elderly and patients with chronic diseases, and sends out an alarm when the system appears abnormal. On the other hand, the remote monitoring of healthy people is realized, to find the early symptoms of diseases, and achieve the purpose of prevention and health care for potential diseases.

MOBIMEDIA 2018, June 21-22, Qingdao, People's Republic of China

DOI 10.4108/eai.21-6-2018.2276601

2 Overall design of the system

The NB-IoT-based wearable monitoring system is divided into three parts: wearable device, service center and monitoring platform. The wearable device can collect the physiological data of the user, by wearing which, the user can collect the physiological data of blood pressure, body temperature, ECG, heart rate, movement and sleep all the time. The collected data is transmitted to the nearby NB-IoT base station through the NB-IoT module and stored in the service center. After receiving the data, the service center parses, analyzes, processes and stores them. The monitoring platform monitors the physiological data from three parties, such as users, guardians and medical staff. The overall structure diagram of the system is shown in Figure1.

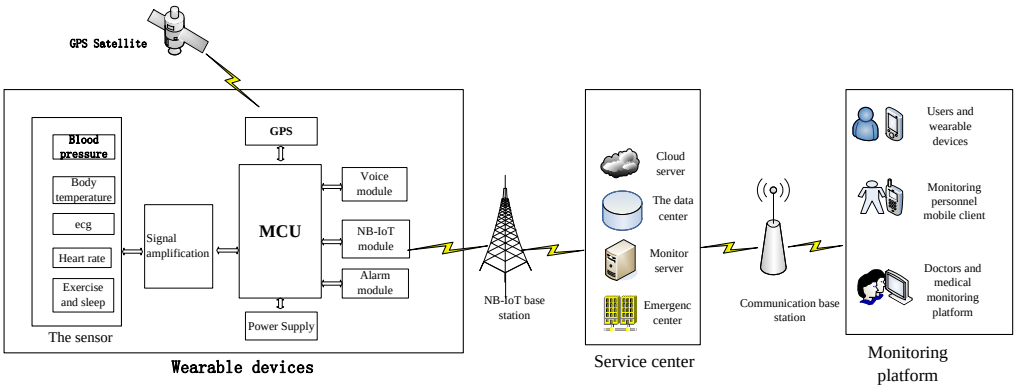

Figure 1 Overall structure of the system

2.1 The wearable device

The wearable device mainly realizes the functions such as the collection of physiological data, one-key help and voice reminding, which is mainly composed of MCU, NB-IoT module, sensors, voice module, GPS, alarm module and power supply.

(1) MCU is used to receive physiological data collected by sensors, acquire GPS location information, and control NB-IoT module to transfer physiological data and location information to service center.

(2) The NB-IoT module is used to transmit the collected data to the nearby NB-IoT base station in real time, which is then stored in the service center, to realize automatic uploading of the data.

(3) Sensors are used for collecting physiological data, which is relatively weak. So it needs to be amplified, and then the interference noise is filtered through the low pass filter. After being processed by the pre-front circuit, the analog signal is converted into a digital signal and input to MCU.

(4) The voice module is used to realize reminding of abnormal situations. When sensors monitor abnormal signs of users, or the physiological indicators exceed the threshold, the voice module will remind users to prevent disease or seek medical advice in time. The way of voice broadcasting greatly reduces power consumption, prolongs standby time, and is more humanized and intelligent.

(5) GPS is used to get the user's current location. There are a large part of the elderly living alone in China, whose travel safety is often worrying. The built-in GPS can obtain the real-time accurate position of the user, and transmit the location information through the NB-IoT module to the service center for storage, and their children or guardian can check it at any time through the mobile client.

(6) The alarm module is used to realize one-key help. When the user is in the case of no one around, feels discomfort and needs emergency, then just push the alarm button, the NB-IoT will send the alarm information and location information to the emergency center and the guardian, and the medical institution will promptly dispatch rescue personnel, to handle the dangerous situation, and ensure that the user can get effective treatment in the shortest time.

2.2 Service Center

The service center is composed of cloud server, data center, monitoring server and emergency center, as the center of data and service in the whole system, which can realize information interaction with wearable devices and monitoring platform, and provide the service of data analysis, query, alarm, and reminder.

(1) The cloud server stores massive physical data and historical data.

(2) The data center stores users' physiological data and identity information of users, guardians and medical staff. Guardians and medical staff are able to check data of the data center remotely through the monitoring platform.

(3) The monitoring server is used to monitor physiological index, provide real-time alarm in terms of abnormal situation, and alert the medical staff and guardians for emergency.

(4) The emergency center is connected with the monitoring server. When the user has the request for first aid, it can immediately notify the emergency center, and the emergency center will immediately take measures according to the feedback information from the monitoring server.

The wearable devices complete data acquisition, and send the data to the service center through NB-IoT. The health condition of the user or physiological condition in a certain period of time will be analyzed and displayed in the form as curves, charts, assessment report and other visual form in real-time [2], which is convenient for the guardian and medical staff to intuitively understand the health condition of the user. When the data reaches a certain order of magnitude, it can be analyzed from the overall macro level.

2.3 Monitoring platform

The monitoring platform works in three aspects:

(1) Users and their wearable devices: The service center provides users with appropriate information and recommendations based on the monitored data, and sends them through NB-IoT to wearable devices. It can help users to understand physiological conditions effectively by voice broadcasting, and alerts them for emergency in time, when there is abnormal situation.

(2) Guardians and their mobile client: The guardians can obtain the data through the mobile communication base station, to check the physiological indexes of the person under guardianship in real time, understand their health status, and take the duty as the guardian. Once the background monitors the abnormal situation, the server will send the abnormal message to the guardian's mobile client directly through the communication base station. After

confirmation, the guardian can take immediate action to ensure the health and safety of the person under guardianship [3].

(3) Doctor and monitoring platform: the physiological parameters database is set up for remote check by the medical staff, to timely control the indicators, prevent the occurrence of potential diseases in advance, provide patients with accurate and effective medical services according to clinical diagnosis, and give reasonable and timely treatment advice in case of abnormality, which can achieve the monitoring of vital signs and the prevention of chronic diseases.

3 Key technologies of the system

3.1 NB-IoT

NB-IoT, namely Narrow Band Internet of Things, has been the leader of the low-power wide-area network (LPWA) technology, because of its advantages such as wide coverage, low power consumption, low cost, multi connection, and long life, and has also got the attention of domestic and foreign industry, and a number of companies and organizations in the world are vigorously promoting its development [4].The main features of NB-IoT are as follows:

3.1.1 Wide coverage

NB-IoT improves coverage through uplink Inter-site CoMP technology and duplication mechanism. In the narrow band design, the uplink bandwidth can be 3.75KHz or 15kHz, the downlink bandwidth is 180kHz, and it can support retransmission for the maximum of 128 times.The communication capability is greatly enhanced and the coverage area is expanded by 100 times, which result in the continuous monitoring of the wearable monitoring system.

3.1.2 Low power consumption

The appearance of NB-IoT is mainly aimed at low frequency and low frequency, while power saving mode (PSM) and eDRX technology in the 3GPP standard make NB-IoT has the characteristic of low power consumption, which can achieve long standby by simplifying the wireless transmitting protocol, shortening the sending/receiving time and other measures, and the endurance time of wearable devices is increased to 5-10 years from the past few days and months.

3.1.3 Multi connection

In 2017, there are more than two hundred million wearable devices in the world, and by 2018, the global market will reach 12 billion dollars. There will be more wearable devices connected to the Internet in the future. NB-IoT supports multi connection, of which one sector can support 100 thousand devices into access at the same time, up 50-100 times compared to existing wireless technology.

In the design of the NB-IoT-based wearable monitoring system, it applies SARA-N2 communication module based on NB-IoT technology, which has the features such as low power consumption, low cost, wide-area transmission, supporting a large number of nodes, fast and safe, superior performance and battery continuous navigation, has strong anti-interference ability, and can be used in all kinds of environment.

3.2 Sensor

The sensors of wearable devices mainly realize the monitoring of blood pressure, body temperature, ECG, heart rate, movement and sleep. They should be characterized by small volume, low power consumption, high stability, high reliability, easy integration and easy sensing.

3.2.1 Blood pressure

Hypertension is the most common chronic disease, with the high rate of disability and death, which brings a heavy burden to the family and society [5]. It is an ideal state that systolic blood pressure is below 120mm Hg and diastolic blood pressure is below 80mm Hg. And when systolic blood pressure exceeds 140 mm Hg and diastolic pressure exceeds 90 mm Hg, it can be judged to be hypertension. In addition to daily prevention, effective monitoring of blood pressure and timely medical treatment, can significantly reduce the harm caused by hypertension. The system uses BP300T blood pressure sensor, which is a pressure sensor for electronic sphygmomanometer, equipped with the balloon cuff, as well as the advantages of high accuracy, small size, high stability and so on. The cuff pressure is sampled through the trachea and BP300T chip connected with cuff, following by amplification and filtering, and then MCU reads the value of blood pressure through the serial port, analyzes the data, and transmits them to the server through the NB-IoT module.

3.2.2 Body temperature

The beginning of many diseases is usually accompanied by the rise of body temperature. And it is an important basis for judging health, that body temperature is maintained in a constant range. The system uses DS18B20 temperature sensor to realize the collection of body temperature, by the single bus and integrated chip technology, which can directly convert the collected temperature signal into digital signal for storage, with the advantages of small volume, low power consumption, high accuracy, and not prone to the interference.

3.2.3 ECG

ECG is an important reference index for the assessment of human health, which plays an important role in the prevention and monitoring of heart disease. The system uses BMD101 as a collection chip [6] for ECG signal, which has the advantages of low power consumption, small volume and low cost. The ECG signal collected by the BMD101 chip is amplified, filtered, and analog-to-digital converted, and is then output to MCU through the serial port.

3.2.4 Heart rate

Under a healthy state, the heart rate of the human body is maintained in the range of 60 times / minute -120 times / min. The heart rate signal is a weak physiological signal, which is easily disturbed by the external environment. So the collected signals need to be amplified by the high impedance differential amplifier circuit. The amplified signal is greatly disturbed and the heart rate signal is extracted by multi loop negative feedback band-pass filter. The system adopts SON7015 heart rate sensor, which integrates a low noise preamplifier, to measure the intensity change of reflected light caused by small changes of arterial blood vessels during heart wave, and then obtain the weak signal of heart rate. After amplification and noise reduction, the heart rate signal can be obtained. It can be regarded as an abnormal situation that the heart rate is more than 120 times / minute in the normal state. Then judge that the user

is in a state of non- movement, by the movement sensor, and the alarm is given when the collected heart rate is over 120 times / minute.

3.2.5 Movement perception

Movement perception sensors are used to monitor the movement and sleep status of users, and the influence of sleep on health cannot be ignored. Long-term insufficient sleep or insomnia will decrease human immunity and make them easily suffer from various diseases. The right amount of movement following the doctor's orders is of great benefit to the physical and mental health of the elderly. The system obtains the monitoring information of movement and sleep, by the three-axis acceleration sensor MPU6050, which uses X, Y and Z acceleration in three directions to detect different movement states, integrates with built-in gyroscope, and makes use of GPS location, to realize the statistics of movement volume. The quality of sleep is monitored through accelerometers, gyroscopes and photoelectric sensors.

3.3 Main control chip

Most wearable devices on the market can be divided into three types, that is, MCU (Micro Controller Unit), SoC (System on Chip) and AP (Application Processor). Considering the comprehensive factors of performance, power consumption, price and market, the system selects STM32L4 of ARM Cortex-M4 processor core, of which the intelligent architecture has excellent performance and energy source advantages, and ultra-low-power multi-mode power management can maximize energy efficiency.STM32L4 is a combination of low power and high performance, of which the package size is very suitable for wearable device, and the power consumption is only 4 nA. It is an ideal micro controller for wearable devices, medical monitoring systems and other energy sensitive applications.

The well-known Fitbit, Samsung GALAXY Gear2, and Plump hand ring adopt STM32 as the main control chip.

3 Design of system software

The system initiates first after power on, and GPS gets the user's current location information, then the physiological signals are collected, which are transmitted through the NB-IoT module to the service center. The service center determines whether the data exceeds the warning value, and then starts the alarm if it exceeds. After one times of collection, the cycle enters the next collection, so as to realize the 24-hour monitoring. The system flowchart is shown in Figure 2.

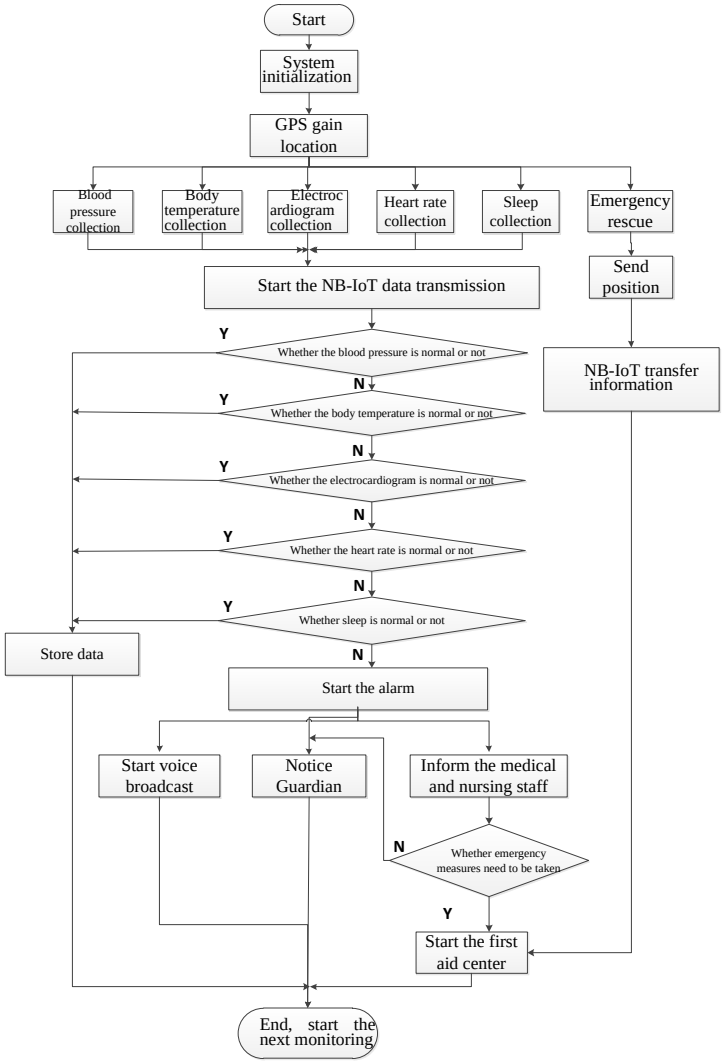

Figure 2 Flow chart of the system

4 Conclusion and Prospect

Once the sensor completes data acquisition, NB-IoT automatically transfers data to the service center, and realizes uninterrupted real-time monitoring, which is suitable for various occasions and supports more access to sensors. At present, NB-IoT has been deployed in a large-scale. And it is believed to be widely invested in business in the near future, and NB-IoT will bring a technological innovation to the field of wearable devices and medical health.

With the increase of aging population and chronic disease groups, wearable monitoring system has become more and more important as the auxiliary medical treatment,which can not only be used to prevent the sudden disease, but also can be used as a monitoring method of

health status. It is an important basis for diagnosis and tracking of curative effect [7]. Wearable devices usually provide continuous real-time monitoring, and produce a large amount of data, which can be analyzed in depth with the help of large medical data platform and the processing technology of big data based on cloud calculation [8], to mine the hidden relationships among data attributes. It has important significance for the prevention and health study of human diseases.

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