Design Engineering

ISSN: 0011-9342
Issue: 1 | Pages: 645 - 652

Design and Implementation of Real-time Physiological Parameters Monitoring System Based on WBAN

Liquan Chen [1] ,You Li [1],Fengjun Shen [2], Zhaoqimeng Shan [3], Jiaxuan Chen [4*]

[1]Department of Physical Education and Sports Science, Mudanjiang Normal University, Mudanjiang

[2]College of Sport Science and Physical Education, Myongji University, Yongin-si, 17058, Republic of Korea

[3]Graduate School of Business Administration, The University of Suwon, 03016, Republic of Korea

[4.] International Elite College, Yonsei University, Wonju, 26493 South Korea

*Corresponding Author: Jiaxuan Chen

Abstract:

The design and implementation of real-time physiological parameters monitoring system based on WBAN is researched in this paper. In the existing multi physiological parameter monitoring system, each sensor and acquisition unit adopts integrated mode in physical layer and data link layer. This mode is not conducive to wearable sensing with multiple physiological parameters and wireless networking. In this paper, a new method based on wireless body area network (WBAN) for wireless sensor, acquisition and front-end networking of multiple physiological parameters is proposed. With the mode of "wearable wireless sensing + mobile remote wireless transmission", the method provides technical support for wireless monitoring of multiple physiological parameters to family health monitoring and disease early warning of sub-health population.

Keywords: *Data analysis, WBAN,Real-time, Physiological Parameters*.

I. INTRODUCTION

At present, the multi physiological parameters monitoring system, including ECG, blood pressure, oxygen saturation, respiratory rate, pulse, body temperature, has played an important role in bedside monitoring, human sub-health online monitoring and disease warning. However, the existing multi physiological parameter monitoring system has the following problems in clinical application [1-2]: Firstly, multiple physiological parameter detection and sensing units are integrated in an embedded module, that is, ECG, blood pressure, blood oxygen and other parameters detection units are integrated in the physical layer and data link layer through wired mode. In this way, it is impossible to disassemble and combine each functional module, which

ISSN: 0011-9342
Issue: 1 | Pages: 645 - 652

leads to the problems of large volume of sensor, complex wiring and inconvenient use of users. Moreover, the damage rate of sensor lead wire is very high, and the signal quality is easy to be affected by human physiological activities and movements, which is unfavorable to the use of general users;Secondly, the current multi physiological parameter sensing unit and remote transmission terminal cannot be free networking, the data transmission terminal can only receive the data of the acquisition unit in a fixed and passive way, and users can not selectively use one or several sensor acquisition units of the multi physiological parameter monitoring system. At the same time, users can not use general mobile communication terminals (especially smart phones) to transmit multiple physiological parameters, which limits the extension and promotion of telemonitoring system medical services to a certain extent.

With the increasing types of physiological parameter monitoring and the number of users, both patients and doctors put forward higher requirements for the medical quality and service level of remote monitoring [3-5]. How to further improve the signal quality and reliability of monitoring parameters, how to significantly improve the convenience and comfort of monitoring environment, and how to further promote multi-physiological parameter monitoring to users' daily health monitoring and home monitoring have become the problems that must be solved in the development of telemedicine and digital medicine. However, the existing remote monitoring system with multiple physiological parameters does not fully possess the above attributes.In recent years, with the popularity of smart phones and the rapid development of mobile Internet, it is technically possible to directly use mobile phone terminals for online monitoring of multiple physiological parameters. In addition, with the development of various short-range wireless communication technologies, the networking quality and transmission bandwidth of multi-sensor networks have been further improved, which also provides a strong technical support for the development of multi physiological parameter architecture in the direction of wide popularization, large amount of data and strong real-time. Therefore, it is necessary to study a new front-end sensing and networking method of multi physiological parameters remote wireless monitoring system suitable for ordinary users.

II. GENERAL FRAMEWORK OF MULTI PHYSIOLOGICAL PARAMETERS MONITORING SYSTEM BASED ON WBAN

Wireless body area network (WBAN) is a micro communication network centered on human body and composed of various sensors and personal terminals distributed on human body, clothes and even inside human body [6]. Through WBAN, users can communicate with their personal electronic devices, such as PDA, smart phone, etc., and exchange and share these data with node elements on the network through the Internet. WBAN turns human body into a part of communication network, and makes wearable computing and pervasive computing provide technical support and services for people's daily health monitoring.

The remote multi physiological parameter monitoring system proposed in this paper is composed of front-end body area network node, mobile terminal and data processing server.

ISSN: 0011-9342
Issue: 1 | Pages: 645 - 652

The system structure is shown in Figure 1.Among them, the front-end acquisition part adopts the separate design of each parameter unit, and takes MSP430 single chip microcomputer of TI company as the control core, which is mainly responsible for collecting and sending patient physiological data; The mobile terminal adopts 3 G smart phone, which mainly realizes short-range networking and remote data transmission of multiple physiological sensing units; In fact, the data processing server is a private cloud platform, which is mainly used to store and analyze massive data of cluster users with multiple physiological parameters, and give corresponding diagnosis suggestions according to the analysis results.The specific working principle of the system is as follows: each separated wearable sensing unit sends the collected physiological signals such as ECG, blood pressure and oxygen saturation to the mobile terminal (smart phone) through WBAN short-range wireless networking, then verifies and compresses the multiple physiological parameters, and then remotely sends them to the cloud for analysis and diagnosis via 4G mobile communication network, at the same time, the analysis results are pushed to doctors and users' front ends respectively [7].

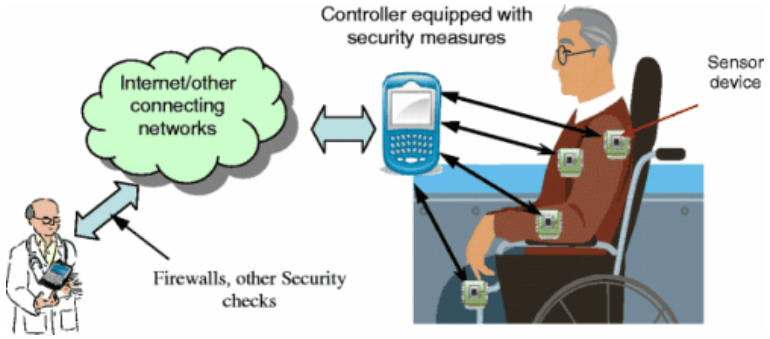

Fig 1: System architecture diagram

III. DESIGN OF MULTI PHYSIOLOGICAL PARAMETERS WBAN SENSOR NODE AND NETWORKING

3.1Design of WBAN Sensor Node with Multiple Physiological Parameters

The function of WBAN sensor node with multi physiological parameters is to collect the multi physiological data of users and send them to the mobile smart phone terminal through short-range wireless. Therefore, each sensor node contains three modules, namely data acquisition, MCU control and short-range wireless transmission, as shown in Figure 2.

In view of the design concept of wearable and lead-free, the separate acquisition unit is designed for ECG, blood pressure, blood oxygen and other physiological parameters in the front-end of data acquisition, which overcomes the problems that must be considered when using centralized data acquisition: different frequency and recording interval of each parameter lead to control difficulties. At the same time, the separate acquisition design also reduces the mutual interference between the acquisition units. The controller of the multi physiological data sensing unit adopts the MSP430 of TI company. The reason is that the MCU is 16 bits, and the processor adopts the reduced instruction set (RISC) structure. The addressing mode is very rich and has strong embedded processing ability;At the same time, because the power supply voltage

ISSN: 0011-9342
Issue: 1 | Pages: 645 - 652

of MSP430 is 1.8 ~ 3.6V, when it runs at 1MHz clock, the chip current is about 165 μ a, which is conducive to the low-power design of separated wireless sensor. In addition, the wireless transmission module of the node is mainly connected with MSP430 through serial port. Due to the use of separate multi physiological parameter sensing and transmission, each sensor node needs to configure a wireless transmission module, and multiple wireless transmission modules must be networking to ensure the reliability and coordination of multi physiological parameter transmission. Similarly, when wireless transmission module is added to each node, the reliability and stability of wireless data transmission must be considered, as well as the low-power design of wireless transmission module.

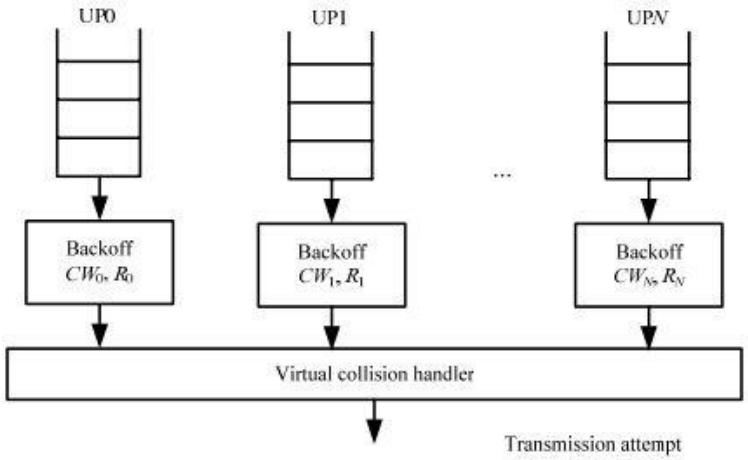

Fig 2: WBAN networking diagram of wireless sensor node with multiple physiological parameters

3.2Software Design of WBAN Sensor Node

The software of data acquisition terminal runs in MSP430, which mainly controls the front-end data acquisition and transmission. After receiving the start command sent by the mobile phone terminal, the multi-physiological parameter sensor node processor first collects and processes the signal, and then the wireless transmission module forwards the processed data to the mobile terminal. In order to ensure the stability of data transmission in embedded environment, data CRC check and response mechanism is introduced to ensure the validity and integrity of data transmission.

In order to further reduce the power consumption of each sensor node, the design of variable data sampling rate and data recording interval is adopted, that is, after analyzing the data uploaded to the cloud, the server sends out control commands according to the current physiological status of patients, and the terminal changes the sampling rate and recording interval accordingly to complete the feedback control of each sensor node. In addition, the node software also monitors and warns the working condition and power of the power module to ensure the stability and reliability of the system.

ISSN: 0011-9342
Issue: 1 | Pages: 645 - 652

IV. SOFTWARE DESIGN OF MOBILE COMMUNICATION TERMINAL WITH MULTIPLE PHYSIOLOGICAL PARAMETERS

With the wide application of 3G network, the function of mobile terminal is enhanced, the quality of end-to-end communication and data transmission rate are greatly improved, and the relationship with users is more close. This system uses smart phone as the repeater of multi physiological parameters short-range wireless networking and remote wireless transmission, which is conducive to the popularization and promotion of the system. As the Android platform is widely used in the existing smart phone operating system, the software design and development of wireless sensing and transmission function of multi physiological parameters is carried out in the Android system environment.

4.1Business Logic Design of Multi Physiological Parameters Monitoring for Mobile Terminal

In the multi physiological parameters wireless sensing and transmission system, the core function of mobile terminal is to realize the short-range network collection of sensor data, remote transmission of multiple physiological parameters to the cloud server, and local storage of data.

The work flow is as follows: after the mobile phone terminal runs the initialization program, first reset the sensor nodes and synchronization time, then connect and network the Bluetooth modules of each sensor node, and then connect the server through 3G wireless communication for user login and authentication.When the data path of "sensor node-mobile phone terminal-cloud server" is connected, it starts to receive, process and remotely transmit the data sent by each sensor node, and can also store the collected physiological parameters in SD card according to the needs of users and doctors. In addition, according to the specific needs, the functions of multi physiological parameter compression, signal detection and preliminary data analysis can be added in the mobile phone terminal.

4.2Design of Bluetooth/3G Gateway for Mobile Terminal

The gateway model of Bluetooth/3G protocol of mobile terminal is shown in Figure 3, and the network management layer is responsible for the conversion of two kinds of negotiation. The software structure of Bluetooth gateway mainly includes three parts: initialization of Bluetooth micro-network, initialization of 3G network, and data transmission of multiple physiological parameters. In the initialization of Bluetooth micro-network, AT command needs to be sent to Bluetooth module through serial port to complete pairing with smart phone and data transmission.

After the mobile phone is bound with the Bluetooth gateway address, the time-sharing one to many data transmission is carried out. In the gateway management layer, the mobile phone parses the data from the Bluetooth gateway, and sends the data to the remote server cluster through the 3G module. Similarly, the information transmission is bidirectional. The mobile phone can also send the control information from the cloud server cluster to the MCU of the sensor node through Bluetooth, so that the closed-loop feedback operation and control of data

ISSN: 0011-9342
Issue: 1 | Pages: 645 - 652

perception can be realized for the front-end multi physiological parameter sensing unit according to the monitoring results and service content provided by the cloud.

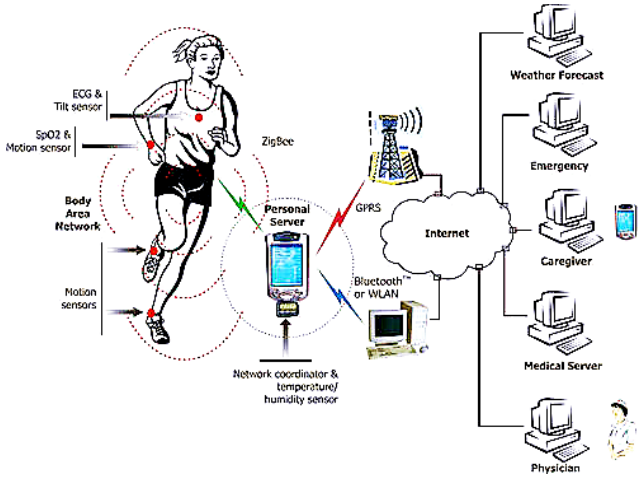

Fig 3:Schematic diagram of Bluetooth / 3G gateway

V. TEST RESULTS AND ANALYSIS

According to the above design ideas and methods, the multi physiological parameters front-end wireless sensor and networking are tested.Firstly, ECG, blood pressure, blood oxygen saturation and their corresponding Bluetooth 2.0 modules are integrated on three MSP430 single-chip computers to form three wearable wireless sensor nodes with multiple physiological parameters; Then, on the Android smartphone, the corresponding gateway program and application program are developed, and each wireless sensor node is networked and bound to realize wireless collection, processing, storage and remote wireless transmission of multiple physiological parameters. At the same time, building a special test cloud server is convenient to verify the consistency of data transmission and the feasibility of feedback control.

The monitoring page of smart phone terminal includes main menu and monitoring page. Through entering the monitoring page, the module of ECG, blood pressure and blood oxygen saturation is connected wirelessly, and the data is transmitted in time. Operate each module in turn to establish a connection. The Bluetooth indicator light changes from red slow flashing to blue constant on, indicating that the networking is successful. The list of connected modules can be found on the smartphone, and the modules can be closed and data transmission can be started.

Figure 4 shows the collected 3-channel ECG data, the sampling frequency is 250Hz, using hexadecimal storage. Through the analysis of the received hexadecimal data, the data acquisition is effective.

The test results show that the mobile phone terminal can control the initialization and synchronization time of multi-sensor nodes, and realize the network acquisition, processing, storage and remote transmission of multi-physiological parameters; In short-range wireless networking transmission and 3G long-distance wireless transmission, the phenomenon of data packet loss and data congestion with multiple physiological parameters is obviously reduced,

ISSN: 0011-9342
Issue: 1 | Pages: 645 - 652

and the data of SD card is in good consistency with the data of cloud server.In addition, the feedback information from the cloud server can be sent down to the mobile phone, and the sensor node can be switched on and off and standby.

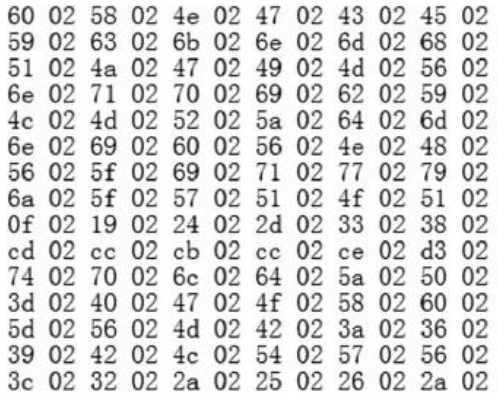

Fig 4:Multi physiological parameter data (ECG data)

VI. CONCLUSION

Aiming at the problems of inconvenient use, low reliability and poor versatility of the existing multi physiological parameters monitoring system, a new method of multi physiological parameters sensing and acquisition based on "WBAN wearable wireless sensor + smart phone networking" is proposed in this paper. In terms of technical implementation, WBAN sensor microgrid technology is used to replace the traditional wired lead integrated acquisition mode, which not only reduces the lead line interference and signal motion artifacts, but also improves the quality of physiological signal acquisition, and solves the problems of high lead line failure rate, inconvenient monitoring and inflexible use in the existing multi parameter monitoring system;In the process of data sensing and transmission of sensor nodes, the low-power design combined with sleep and wake-up mechanism is adopted, which reduces the power consumption of front-end data acquisition and processing and can effectively improve the online monitoring service quality; Using smart phones to realize WBAN networking, initialization, synchronization and remote data transmission of sensor nodes can not only realize front-end data acquisition, processing and transmission, but also improve the universality of the whole monitoring system, which provides technical support for further expanding the audience of multi-physiological parameter monitoring system.

ACKNOWLEDGEMENT

The study was supported by “National Training Research Project of Mudanjiang Normal University in 2019 (No. GP2019007)”. The study was supported by“Project of Basic Research Operating Expenses of Education Department of Heilongjiang Province in 2020,China (No. 1355ZD017)”.

ISSN: 0011-9342
Issue: 1 | Pages: 645 - 652

REFERENCES

[1] Wong, L. H., Chai, C. S., Zhang, X., & King, R. B. (2015) Employing the tpack framework for researcher-teacher co-design of a mobile-assisted seamless language learning environment.IEEE Transactions on Learning Technologies8(1): 31-42.

[2] Kim, H., Shin, H., Kim, H. S., & Kim, W. T. (2018) Vr-cpes: a novel cyber-physical education systems for interactive vr services based on a mobile platform. Mobile Information Systems 2018(PT.3): 1-10

[3] Ji, X. (2019) Community guidance model based on interactive multimedia system.Multimedia Tools and Applications78(4): 4723-4741

[4] Chang, C. K., Reisman, S., & Tovar, E. (2017) Advances in learning technologies.Computer,50(5): 14-17

[5] Chacon, R., Codony, D., & Toledo, A. (2017) From physical to digital in structural engineering classrooms using digital fabrication.Computer Applications in Engineering Education,25(6): 927-937

[6] Ahmed, & Ali, A. (2015) A comparative study of qos performance for location based and corona based real-time routing protocol in mobile wireless sensor networks.Wireless Networks21(3): 1015-1031

[7] Friedman, A., Hahn, K. A., Etz, R., Rehwinkel-Morfe, A. M., Miller, W. L., & Nutting, P. A., et al. (2014) A typology of primary care workforce innovations in the united states since 2000.Medical Care52(2): 101.