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Design and Implementation of Intelligent Medical System for Chronic Diseases

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Abstract: With the continuous improvement of human living conditions and the aggravation of global aging level, chronic diseases such as hypertension and diabetes continue to plague human health. Chronic diseases have long duration, difficulty in treatment and high cost. Research on an effective intelligent system to prevent, recognize and control this kind of disease becomes an effective means to fight against this kind of disease. This paper takes chronic diseases as the research object, and proposes a design of intelligent medical system for chronic diseases based on semantic matching by the adaptation of ZigBee technology in the front-end data acquisition. Through the ZigBee wireless sensor network, this system sends the physiological parameters collected by various medical sensors to the intelligent medical system, and innovatively proposes semantic matching algorithm to solve the queuing problem of data transmission, to ensure the accuracy of data transmission. This system employs the improved spatial vector model to process the data uploaded, and uses AES encryption algorithm in the process of data transmission to ensure the security of data transmission. The realization of the intelligent system provides a scientific means of disease management for chronic disease patients, and realizes the effective management of chronic disease, which meets the design requirements and receives great patients' evaluation.

Keywords: Smart Medical Care, ZigBee, Semantic Matching

1. Introduction

From 1990 to 2017, the morbidity of chronic diseases with high incidence in China had been increasing continuously [1]. According to *China National Health and Nutrition Big Data Report 2018*, 20% of Chinese suffer from chronic diseases, and chronic disease mortality was 86%. Therefore, it is crucial to effectively prevent and control chronic diseases.

At present, the main way of chronic disease prevention and treatment is to go to hospitals for regular test, and get the treatment on the basis of the corresponding physical data. This passive recording method greatly raises the economic cost and time cost of patients with chronic diseases. It will cause many problems: firstly, it is unable to check the patient's continuous vital signs data; secondly, it is impossible for patients to get their own condition on time; thirdly, it is liable to doctors' misjudgment.

With the development of Internet, people's life has been profoundly changed. In-depth interviews with 91 employees in different positions from 11 grassroots medical and health institutions since July 2019 show that the efficiency of mobile medical care in the surveyed areas has appeared [2]. With the means of the Internet, with the carrier of the mobile terminal, intelligent medical treatment founded on the units of family is a new trend. Therefore, it is of great significance to develop an intelligent data analysis platform to record, store, and share and handle various personal health signs in time through wireless transmission.

2. Literature Review

2.1. The Development of WITMED

Chronic diseases can easily cause damage to patients' vital organs such as the brain, heart, and kidneys [3] to seriously affects working ability and quality of life, and its high medical expenses increases the burden of economy on society and families. Due to the hazards and characteristics of chronic diseases, researchers all over the world have presented various methods for preventing, monitoring and treating it from different perspectives.

In the 1950s, American scholar Wittson had used two-way TV systems in medical field. In the same year, American scholar Jutra had founded teleradiology. With the emergence of various new telecommunication technology, scholars kept providing health care using all sorts of communication technology. Therefore, the word "Telemedicine" arose. Until now, the development of foreign WITMED (Wise Information Technology of med) is divided into three stages:

The first stage refers to the middle of last century when Network technology was just emerging. By the limitation of hardware performances and the immature internet technology, it could not meet the data transmission requirements for telemedicine. Traditional phone calls were adopted as the main way of communication between patients and doctors.

At the end of the last century, the rapid development of semiconductor technology drove the revolution of information technology. This is the second stage of the development of WITMED. During this stage, information technology was connected with medical health care more closely. Most data were transferred by satellite and ISDN (integrated service digital network). TV links were put into use in mental health services and other medical treatment. With the great improvement of the data transmission capability, rapid development in telemedicine consultation and distance transmission of medical images occurred [4]. At this stage, telemedicine had made considerable progress.

In recent years, with the popularization of mobile terminals (mobile phones, tablets) and the rapid development of the Internet, Telemedicine starts to combine with big data, artificial intelligence, cloud computing, cloud services and other technologies. This is the third stage of the development of WITMED. At this stage, telemedicine has gradually transitioned to WITMED, and developed from precision medicine to disease prevention [5]. Energy-efficient Zigbee-based wireless sensor network (WSN) occupies a major role in emergency-based applications [6]. Kumar establishes an enhanced shortcut tree routing-based geographic location (ESTRBGL) protocol [7]. Haji Bagheri Fard present methods based on deep learning algorithms to achieve high classification accuracy [8]. Zigbee has been implemented on the Health Care Profile. As an alternative for aiding healthcare systems, sensors and wearable devices are used for monitoring patient physiological data to help guide health services or the self-care of patients [9]. Detecting physiological signals in the daily life of the population can effectively grasp the health status of the people in the area, and provide an important reference for the diagnosis and prevention of chronic diseases [10]. In this telemedicine stage, it gradually focused more at community, families and individualized care [11].

2.2. Literature Review

Due to the late development of information technology in China, our Wise Information Technology of med (WITMED) starts later than foreign countries. Since the end of last century, some Chinese hospitals and universities have carried out some researches in this field. For example, the General Hospital of the People's Liberation Army (PLAGH) communicated and discussed some diseases with foreign experts through satellites. The third Military Medical University studied on the home digital medical monitoring project, which designs a network system to monitor human physiological parameters using mobile terminals.

With the great progress of mobile communication technology, Internet and WSN technology with low power consumption, some scholars have applied wireless transmission technology to medical detection system. Meanwhile, some also have applied various wireless sensor technology to medical monitoring system. For example, some domestic hospitals use Bluetooth technology to monitor the ward room. And some scholars combined Bluetooth technology with GSM short message to realize the collection and remote monitoring of physiological parameters such as blood pressure [12] and pulse. In the meantime, some other scholars use 4G and the Internet transmission technology to send physiological parameters to the medical system through the Internet or 4G network, so as to realize medical monitoring.

2.3. The Defects of Current WITMED System

There are some defects of the current WITMED (Wise Information Technology of med) system as follows:

(1) The inadequate reliability of data transmission. For example, when using 4G technology and WIFI technology to transmit data, patients must keep focusing on whether the device is online at all times. What's more, the coverage of 4G network and the transmission distance of WIFI are often easy to cause the loss of transmission data.

(2) The problem of power consumption. Chronic diseases patients have to be long-term monitored, however, whether using a WIFI or GPRS, high power consumption will be arouse.

(3) The problems of unitary monitoring data. Chronic diseases patients are always required to be monitored for multiple vital signs simultaneously. At present, ad-hoc network cannot work no matter using GPRS or WIFI devices, and only one kind of vital-sign data can be transmitted at a time.

(4) The problem of data processing. The current WITMED system focuses only on data acquisition instead of processing uploaded data and returning the result.

With the development of Internet of things in recent years, by the advantages of low power consumption, ad-hoc networking and short-distance, ZigBee technology has been in full use [13]. The growing trend of WITMED system shows that a variety of health signs data will be monitored, transmitted, processed and analyzed in real time, the system can process the uploaded data. Finally, the processed data will be sent back to patients and their family doctors.

2.4. Market Demand

As the speedy development of the escalation of people's living standard, China has gradually entered the aging society with an increasing number of patients with chronic diseases and a descent trend of age [14]. According to the statistics of Professor Yang Hongying, there are 212 million patients with chronic disease in China at present. The traditional prevention and treatment greatly increase the economic cost and time cost of patients. Due to the large amount of medical resources occupied by chronic patients, the phenomenon of difficulty and high cost of getting medical service is more prominent.

Since 2014, the central and local governments have formulated a series of policies around intelligent health care, pointing out the direction for the development and construction of it. Attracted by the broad prospect of smart medicine, BAT and other Internet enterprises have participated in the smart medical industry. Alibaba founded Alibaba health [15]; Tencent launched the first AI+ medical product Tencent Meiying in 2017; many large enterprises integrated medical resources through mergers and acquisitions to lay out the intelligent medical industry chain. According to the Research Report on market development and investment trend of China's smart medical industry from 2017 to 2021, the annual compound growth rate of smart medical market reach 29.6% from 2015 to 2020, and the market scale will exceed 50 billion yuan in the future.

3. System Design

Based on ZigBee technology, a design of intelligent medical system based on semantic matching is proposed.

3.1. Overall Framework

When each node is powered on, various devices must be I/O reset and initialized first. Then the coordinator transmits the data collected to the intelligent medical system. The system processes the received information according to the relevant algorithm, and then feeds back the corresponding results to the designated user. The system architecture diagram is as follow:

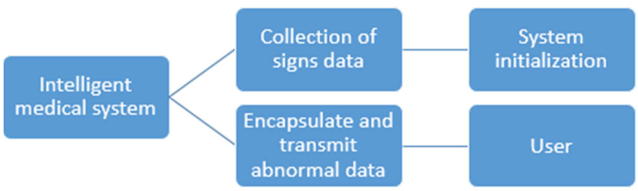

Figure 1. *Overall System Architecture.*

3.2. Data Acquisition Structure Charts

Fast and correct data acquisition is the basis of the platform's efficient operation. Firstly, the initialization function is used to initialize the device and clock, and the signs parameters are read and data is transmitted by the sensor. The process of reading and transmitting data is a loop. The data acquisition structure charts of this system are shown as Figure 2:

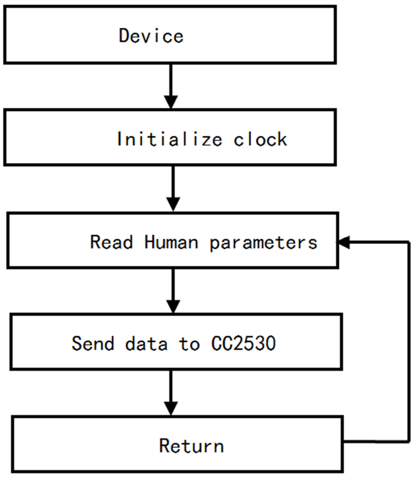

Figure 2. *Structure Chart of Data Acquisition.*

3.3. Data Analysis Roadmap

After receiving the relevant data, the data analysis platform needs to analyze the corresponding data and feedback the processed results to relevant users. The related knowledge base in Figure 3 can be regarded as an expert system. Data analysis roadmap is shown as follows:

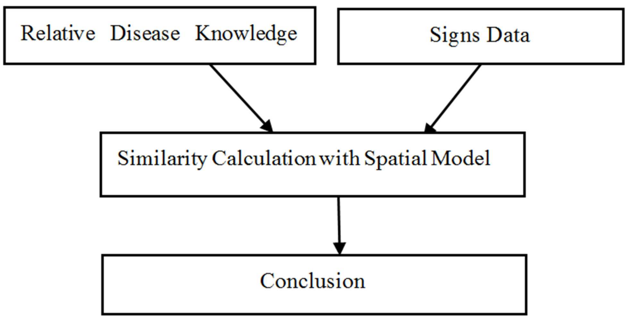

Figure 3. *Data Analysis Roadmap.*

3.4. Data Queuing Algorithm

After collecting patients' physiological information from the node, various physiological sensors will continuously upload them to the coordinator. So the key to this research will be how to keep the integrity and effectiveness of each node's information and then how to process it. The general technique route of the algorithm is as follows: Propose a comprehensive sorting algorithm, on the basis of semantic matching and a first-come-first-served principle. Suppose there are N pieces of information to be sent according to the messages' arriving order, divide each message into many words, and mark each word as Nm, $N_m \in N, 1 \leq \mathrm{m} \leq \mathrm{N}$.

First, match the Word segmentation information by queued delivery with the taglib of the analysis system. If there are X words appearing in the taglib and N-X words not appearing in it, the matching degree of the information is (N-X) / N * 100%. Therefore, it is obvious that the matching degree is a fraction smaller than 100%. When two pieces of information are with the identical matching degree, the first arriving one will be regarded as with high matching degree. Finally, the request is inserted into the message queuing sequence by the matching degree.

The general algorithm of this part is as follows:

Define priority function: $f(x, y) = ax + by + \varepsilon$, with a basic definition as follows:

x: semantic matching degree, $0 \leq x \leq 1$

y: a request arriving at the serial position, $0 < y \leq 1$

a is defined as the weight of semantic matching degree, $0 < a < 1$

b is defined as the weight of serial position of Request arrives, $0 < b < 1$, $a + b = 1$

ε is defined as the disturbance value, $0 \leq \varepsilon \leq 0.1$, with the default as 0.

With the definitions above, $f(x, y)$ can turn to be:

$f(x, y) = ax + (1 - a)y + \varepsilon$, namely $f(x, y) = y + a(x - y) + \varepsilon$. Generally, a is close to $\mu = \frac{1}{2}$, $\sigma^2 = 0$ uni dimensional normal distribution N (μ, σ^2).

Therefore, the process of queuing algorithm based on Semantic matching is as follows:

With the hypothesis that $a = \frac{1}{2}$ (to take one half of the sum)

$x = \frac{5}{10}$ (there are 10 participles in semantic information, of which 5 are matched), $y = 1 - \frac{10}{1+10}$ (Before a new message arrives, assumes that the request queue has 10 participles waiting, then:

$f(x, y) = y + a(x - y) + \varepsilon = 0.294$, therefore, the priority value of the message is 0.294. After all the messages in the queue are calculated according to the above formula, they are inserted into the existing waiting queue indescending order.

3.5. Research on Data Analysis Algorithm

The patients' vital signs data will be transferred into the data analysis system by the sensor, and then the data will be analyzed by the big data system, various signs data will be compared with the characteristic values of related diseases and the results will be returned. This research proposes an improved space vector model algorithm to ensure whether the patient has a related disease by the similarity between the physical signs and the disease on the basis of calculation of the sign value, continuous sign value and the disease characteristic value. An improved SVM calculation method is as follows:

Definition 1 (conception): Define a tuple F= (X, Y, Z), in which x is the collection of all objects is the object property set, Z∈ (X*Y), Z is a subset of X*Y.

Definition 2: let {X1, Y1}, {X2, Y2} is concept form of {X, Y}, {X2, Y2b≠{X1, Y1}.

Definition 3: The concept similarity is calculated as:

$$E_s(X_1, Y_1) = \frac{\delta(Y_1)}{\delta(X_1)}$$

in which $\delta(x) = 0$ $(x \neq 0)$, when x=0, the value is uncertain. $\delta(X_1) = \min_{d \in D} I(X, Y)$

Therefore, The process of calculating the similarity between signs and diseases is as follows:

Calculate the frequency: $Tf(i, j) = \frac{n_{i,j}}{\sum_k n_{k,j}}$, n indicates a certain amount of total knowledge.

Calculate the inverse word frequency: $Idf = \log \frac{|D|}{|\{j: t_i \in d_j\}|}$, D indicates the total number of words.

Calculate the comparability: W (i) =Tf*Idf.

Calculate the final similarity: S (i) =W (i)*E (i), The larger the S, the closer the relationship between this sign and the disease. When S > 0.8, it shows patients with relative diseases.

3.6. Implementation of Data Encryption

Patients' health information involves their privacy. Therefore, it is crucial to guarantee the security of data transmission in the process of information transmission. This system adopts AES (Advanced Encryption Standard) encryption algorithm which is widely used at present.

3.6.1. AES Encryption Process

AES encryption process is shown in Figure 4:

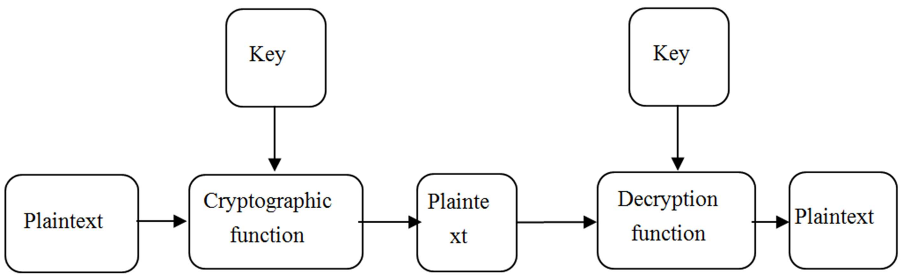

Figure 4. *AES Encryption Process.*

3.6.2. Operational Process of AES

(1) Byte replacement and reverse operation

Byte replacement of AES is a simple operation of table lookup. An S-box and an inverse S-box were defined by AES first. Elements in the state matrix are mapped to a new byte in some way. The inverse operation is to transform by the S-box.

(2) row shift operation and inverse transformation

Row shift is left cyclic shift operation, If the key length is 128 bits, Row 0 of the state matrix is shifted to the left by 0 bytes, The first line moves 1 byte left, the second line 2 bytes left, and the third line 3 bytes left.

Reverse operation perform the reverse shift operation. Row shift operation is shown as Figure 5:

Figure 5. *Row Shift Operation.*

(3) column Mixed Operation

The column mixed transformation is realized by matrix multiplication. The state matrix after row shift is multiplied by the fixed matrix to obtain the confused state matrix. The column mixed operation formula is shown as Figure 6:

$$\begin{bmatrix} a_{00} & a_{01} & a_{02} & a_{03} \\ a_{10} & a_{11} & a_{12} & a_{13} \\ a_{20} & a_{21} & a_{22} & a_{23} \\ a_{30} & a_{31} & a_{32} & a_{33} \end{bmatrix} = \begin{bmatrix} 02 & 03 & 01 & 01 \\ 01 & 02 & 03 & 01 \\ 01 & 01 & 02 & 03 \\ 03 & 01 & 01 & 02 \end{bmatrix} \begin{bmatrix} b_{00} & b_{01} & b_{02} & b_{03} \\ b_{10} & b_{11} & b_{12} & b_{13} \\ b_{20} & b_{21} & b_{22} & b_{23} \\ b_{30} & b_{31} & b_{32} & b_{33} \end{bmatrix}$$

Figure 6. *Formula of Column Mixed Operation.*

(4) key plus calculation

Key plus calculation operates the 128 bit key is XOR bit by bit with the data in the state matrix.

The process of key plus calculation can be regarded as the result of Bitwise XOR or byte level or bit level operation. The calculation is shown as Figure 7:

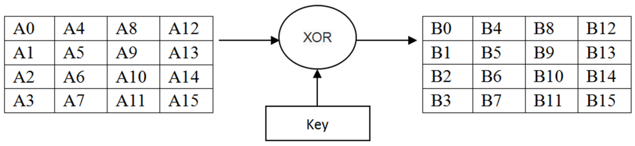

Figure 7. *Key Plus Calculation.*

4. Simulation Test and Result Analysis

4.1. Simulation and Test

After logging in the system, enter the sign input interface and put on the sensor, the system will automatically input the relevant data collected, as shown in Figure 8:

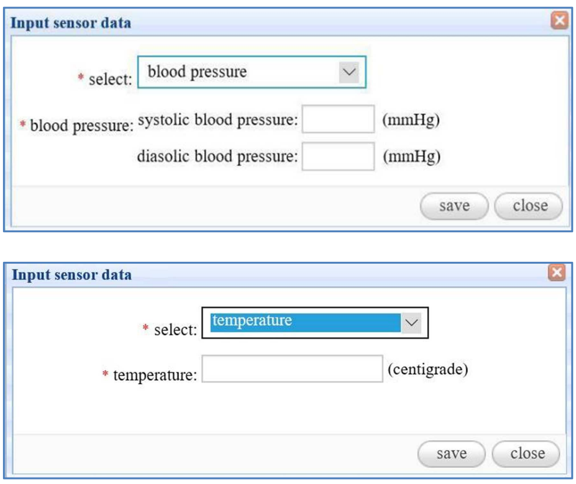

Figure 8. *System Login and Data Acquisition.*

After inputting the data of relevant signs, the system will automatically generate diagnosis & treatment files and health assessment according to the relevant data. If the signs are abnormal, a warning will pop up, shown as Figure 9:

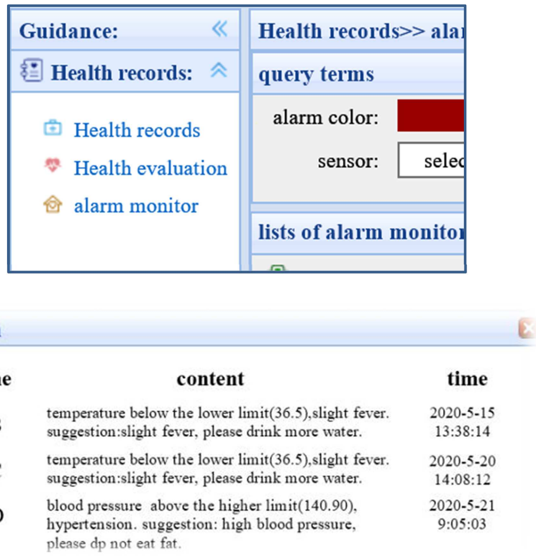

Figure 9. *Health Records.*

The system can also display personal health data in the form of reports and trend charts, as shown in Figure 10:

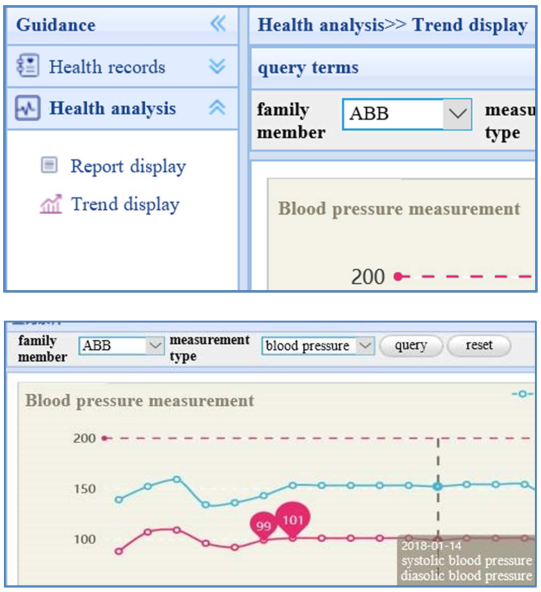

Figure 10. *Health Analysis.*

4.2. Results Analysis

Simulation and test show that the method adopted in this paper is correct. Data acquisition in Figure 8 forms the health records in Figure 9.

The method of backstage data giving warnings and putting forward corresponding disposal measures by big data processing as shown in Figure 9 is better than clustering, and the choice of Space vector model is more accurate than such models as Zigebee Health Care Profile chosen in the references. Through the big data platform, the system intuitively displays the backstage analysis data in the form of reports and trend charts as shown in Figure 9. Compared with the data presentation at present, it is more intuitive.

5. Conclusion

In this study, a design scheme of intelligent medical system based on semantic matching is proposed, with the front-end data acquisition which adopts ZigBee technology, and a semantic matching algorithm is innovatively proposed to solve the queuing problem of data transmission to ensure the accuracy of data transmission. Through ZigBee wireless sensor network, the system sends the physical parameters collected by various medical sensors to the information control terminal, and the improved spatial vector model is employed to process the uploaded data in the process of data transmission by the intelligent data analysis platform, and the security of data transmission is ensured by adopting the AES encryption algorithm in the whole process.

The intelligent system realizes data acquisition, data encryption and processing, and big data analysis. The system can gather and process big health data of chronic patients, and realizes the discovery, tracking and treatment of chronic diseases. The semantic matching algorithm and the space vector model algorithm proposed by the system can be widely used in the data acquisition of clinical big data to provide theoretical and technical support for artificial intelligence to assist disease risk prediction. The intelligent system realizes the data collection of the whole process of outpatient service, examination and treatment, which can provide data support for the precise treatment of diseases.

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References

[1] Cao Xinxi, Xu Chenjie, Hou Yabing... The epidemic trend and prediction of chronic diseases with high incidence in China from 1990 to 2025 [J]. Chinese Journal of Prevention and Control of Chronic Diseases, 2020, 28 (1): 14-19.

[2] Yinmin, Zhang Jin. Research on the adoption and Perceived utility of mobile health care by primary health care workers [J]. Chinese Journal of Hospital Administration, 2020, 36 (05): 397-401.

[3] Liu Lin, Zhou Xuezhong, Zhou Xiaji… Research Overview and Question Discussion on International Clinical Phenotype Ontology [J]. World Science and Technology, 2010, 35 (6): 16-18.

[4] Straker, N, Mostyn, P, Marshall, C. The Use of Two-way TV in Bringing Mental Health Services to the Inner City. The American Journal of Psychiatry. 1976, 133 (10): 1202-5.

[5] Claeke, M, de Folter, J. VERMA, V, Gokalp, H. Interoperable End-to-end Remote Patient Monitoring Platform based on IEEE 11073 PHD and Zigebee Health Care Profile. IEEE Transactions on Biomedical Engineering, 2018, 65 (5): 1014-1025.

[6] Ajmi N, Helali A, Lorenz, P…SPEECH-MAC: Special purpose energy-efficient contention-based hybrid MAC protocol for WSN and Zigbee network. INTERNATIONAL JOURNAL OF COMMUNICATION SYSTEMS. DOI: 10.1002/dac.4637.

[7] Kumar, P. S. Shiju; Ramesh Babu, A. Enhanced STR based geographic location in ZigBee wireless networks: a hybrid PSA. DOI: 10.1080/00207217.2020.1818838.

[8] Haji Bagheri Fard, Mohammad Amin, Chouinard, Jean-Yves…Rogue device discrimination in ZigBee networks using wavelet transform and autoencoders. DOI: 10.1007/s12243-020-00796-x.

[9] Aranda JAS, Dias LPS, Barbosa JLV… Collection and analysis of physiological data in smart environments: a systematic mapping. JOURNAL OF AMBIENT INTELLIGENCE AND HUMANIZED COMPUTINGDOI: 10.1007/s12652-019-01409-9.

[10] Zhang, GQ. A wearable device for health management detection of multiple physiological parameters based on ZigBee wireless networks. DOI: 10.1016/j.measurement.2020.108168.

[11] Li Jian. Clustering and its Application in Text Mining [D]. Xidian University, 2015: 33-35.

[12] Xu Guichen. Research on Medical Case-based Reasoning Based on Ontology [D]. Zhejiang University of Technology, 2014: 78-81.

[13] Chen Yan, Jiang Huimin. Research on Medical Domain Ontology [J]. Information Science, 2014, 37 (7): 23-27.

[14] WHO {Chronic diseases [EB/OL]. WHO. 2016-09-21. http://www.who.int/topics/chronic_ diseases/en/.

[15] Ren S Q, Aung K M M. PPDS: Privacy Preserved Data Sharing Scheme for Cloud Storage [J]. International Journal of Advancements in Computing Technology, 2012, 4 (16): 493-499.