Application of Medical Care Automation System: Taking Gastroenterology as an Example

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Abstract

Recently, a major patient safety incident occurred in Taiwan's large medical center in two consecutive years, which made public opinion stunned. Even in medically advanced hospitals, there will still be problems of manual operation. Therefore, in medical diagnosis, it is very important to use the information and communication technology to verify the patient's medical treatment process and record the medical history, and reduce the occurrence of security concerns due to human error.

This research built an automatic gastroscopy management system. Other than this system help the nurse to automatic record measures the life information of the patient, such as pulse, blood oxygen, blood pressure, and heartbeat before doctors conduct diagnosis and treatment. This system offers long-distance searching function and provides to facilitate the convenience of medical personnel in operating the instrument in different positions. This system uses WSN technology as the patient's physiological information. The use of gastroscope and other data are automatically recorded in the web database.

Keywords: Gastroscopy, WSN, Physiological information, Database management system

1 Introduction

This study is in collaboration with the Department of Gastroenterology at the Medical Center. Although the medical center has sound medical equipment and complete physician capabilities, there are still many manual operations that rely on caregivers in some of the treatment procedures or equipment use procedures. Taking the gastroenterology as an example, because the unit price of the gastroscopy is high, the re-use rate is high after the doctor uses it. In addition to the after-treatment, the nursing staff needs to make a complete record, such as the patient's resume, gastroscopy number, and cleaning record. Because of the large number of patients and the frequent use of the data, when the manual data is used to record the data, the nursing staff is exhausted, and the errors or loss of the manual recording and transcription data may be caused by carelessness. This caused a lack of medical records and pathology for patient treatment. In addition, patients will do basic physical life information checks (such as body temperature, heart rate, pulse, blood pressure, blood oxygen, etc.) before doing regular gastroscopy. The measurement of these data is performed by the nursing staff. In order to reduce the cumbersome and labor-intensive work of the medical staff due to the inspection procedure, the concept and technology of the Internet of Things (IoT) [1] and Artificial Intelligence [2] are applied in the diagnosis of gastroenterology. Therefore, this study cooperated with the Department of Gastroenterology to collect and record the measurement data and life information of gastroscopy using handheld optical electronic barcode device [3], communication technology (IT) and cloud database [4-7]. Successfully combine the above-mentioned manual operations with intelligent IoT mode, integrate front-end sensing and measurement devices, back-end network data exchange, cloud database information storage, etc., to provides high-precision medical process data accuracy and ease of operation.

The various measurement data at the front end of the study transmitted the data to the cloud database through the connection of the miniaturized electromechanical interface microcontroller and the back-end 802.15.4 wireless sensor network (wireless sensor network, WSN) [8]. This study converging by mobile micro-embedded WSN and hospital's medical information management system, data will automatically and low costly transmitted to the database and store the record of using gastroscopy and the vital signs of patient in the Gastroenterology Internal Database.

It can also combine the time saving of medical treatment and the convenience of measurement. This study completes the patient's vital signs, record of

gastroscopy and Gastroenterology intranet automatic medical management system. Its function can be achieved as followed,

(1) The nursing staff doesn't need to carry lots of large-scale instruments around the wards. They only need to carry a simple type of automatic sensing vital sign system.

(2) Produce the data convergence interface which is easy-to-read and easy-to-recognize, including various vital signs, the record of using the gastroscopy and cleaning records and other data in the automated system so that medical personnel can easily determine the value, and save the value every times.

(3) In addition to entering the above information into the hospital medical management system, it can also build a web-based database for Gastroenterology Department to link the Internet and database via webpage, and build an import interface for various collections of automated systems. In order to remote connection query and various data query functions.

In addition to the precise management of gastroscopy used in medical equipment when sensors and medical automated systems are used to treat patients with gastroenterology, medical staff can also install sensors such as body temperature, blood pressure, and heartbeat on patients. Sensors, through Zigbee's network (ex. Star topology, as shown Figure 1), built on the ceilings of numerous floors, can transmit the patient's physical status back to the host computer, and monitor the patient's physical condition on the monitor.

Figure 1. Star topology of Zigbee

In addition to real-time tracking of patient status, this system can also use deep learning technology to record the places where patients often go and the time of infestation, so that the medical staff can know which patients have more frequent contact, and even know where most patients prefer Activity, as shown in Figure 2, such as the corner of a socializing listening or lounge, and these data can be used as the management of patient behavior patterns.
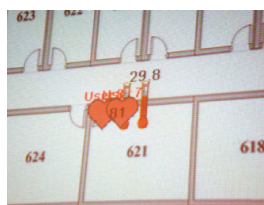

Figure 2. The graph of patient tracing

2 Electronic System Structure

Initially, the gastroscopy model used by doctors for patients, the measurement of life information and the process record after cleaning were manually registered on paper. The process is simple: Patients must first register in the patient book, after completing the medical record number, doctors must first measure the patient's life information (ex. blood pressure, blood oxygen, heartbeat, temperature) before using the gastroscopy to determine whether the patient is suitable for taking gastroscopy. If you need to look at the gastroscopy, use a plastic tube at the same time as the instrument. The function of the plastic tube is to extract gastric acid. This is for subsequent analysis of the disease. Because of the high cost of the gastroscopy, it needs to be reused. When the instrument is finished, the nurse needs to clean the gastroscopy, and record the usage count. After the patient is photographed, the patient will measure the life information again and determine whether the patient has experienced discomfort due to the gastroscopy.

This study measure patient heartbeat information is based on heart rate analysis [9]. It is a method of measuring the degree of change in heart rate. Its calculation method mainly analyzes the time series of heartbeat and heartbeat interval obtained by electrocardiogram or pulse measurement. On an electrocardiogram, the R wave is a more prominent waveform that can be easily detected. The interval between heartbeats is represented by the R wave peak spacing between two adjacent heartbeats, and the frequency of the heartbeat can be calculated. Therefore, the RRI spacing is most commonly used in medicine. To represent the heartbeat interval, as Figure 3.
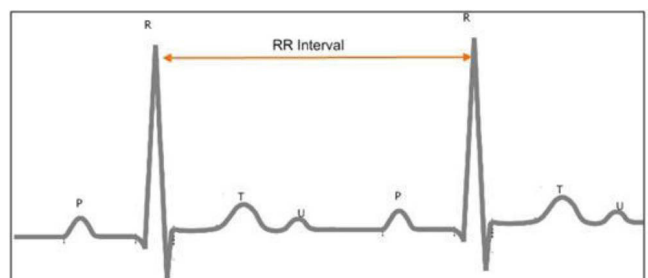

Figure 3. RRI interval (the heartbeat interval)

The analysis of heart rate variability can be divided into time domain analysis and frequency domain analysis. This study uses time domain analysis. The parameters that are commonly used in time domain analysis are as follows:

(1) The mean (Mean) of all normal heartbeat intervals: The unit is microseconds.

The formulas is:

$$MeanRRI = \frac{\sum_{i=1}^{n} RR_i}{n} \qquad (1)$$

(2) The standard deviation of all normal heartbeat intervals, SDNN (Standard Deviation of Normal to Normal): The unit is microseconds. The square of the SDNN is the same as the square of the total power of the frequency domain analysis and represents the total heart rate variability.

The formulas is:

$$SDNN = \sqrt{\frac{\sum_{i=1}^{n}(RR_i - MeanRRI)^2}{n}} \quad \textbf{(2)}$$

The heartbeat rate is calculated in the front-end information platform 1 using equations (1) and (2). Because the nursing staff manually records the gastroscopy used by all patients for observation, the time used is about 50 to 60 seconds (depending on the handwriting speed of each person), plus the amount of patient life information. The test will be longer. However, using the front-end information platform 1 to automate the login method takes only 7-10 seconds, which reduces the working time by 10 times in terms of time efficiency, and the data record is very accurate. It is also very convenient and fast for reducing paper usage and instant access to patient medical records on the Internet.

The blood oxygen, pulse, and heartbeat sensors (computing by eq.1 and 2) that measure the patient's life information in this study use the cooking hack module [10] to import three kinds of data into the embedded module (Arduino). Blood pressure sensor is using Avita Co.'s BPM65ZB sphygmomanometer, measurement range from 30~280mmHg. The scanning gastroscopy, washing machine usage records were performed using a one-dimensional Bar Code barcode and an optical barcode scanner [11]. The life information data can be automatic imported into the back-end information platform via UART USB or Xbee wireless transmission (IEEE802.15.4) (front-end information platform 1) [12]. Blood pressure meter data is transmitted to the back-end information platform through the Bluetooth standard protocol, and the optically scanned data is transmitted via the UART USB. When all measured data is input to the back-end information platform, it is also stored in the hospital's information management system via the wireless network. The automatic control system architecture is shown in Figure 4.

The following will explain each sub-system work situation:

2.1 Front-end Information Platform 1

The front-end information platform 1 mainly measures the life information via the A/D conversion, configures a wireless sensor network terminal node in the patient, and transmits the sensed life data to the information processing platform (PC). Both transmit and receive life information data gathered from the
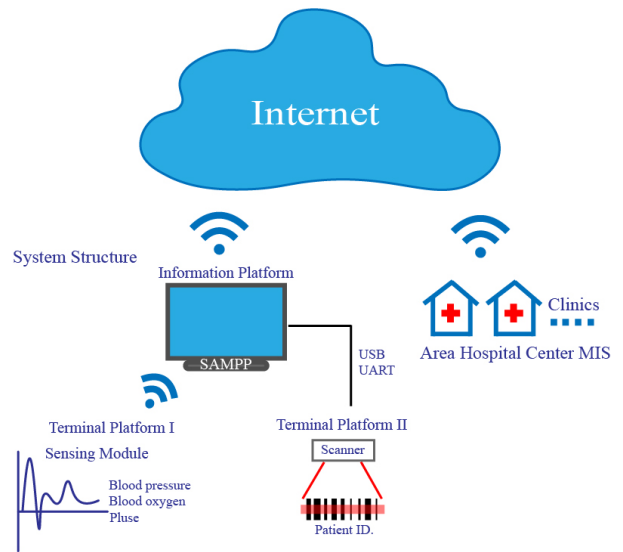

Figure 4. structure of automatic control system

embedded data acquisition module in a peer-to-peer manner and send it to the terminal server. The communication transmission mode is based on the IEEE 802.15.4 protocol and transmits/receives star network communication to complete the network communication. For the function, Xbee is used for the transmit/receive module, and the architecture of the front-end information platform 1 is shown in Figure 5.
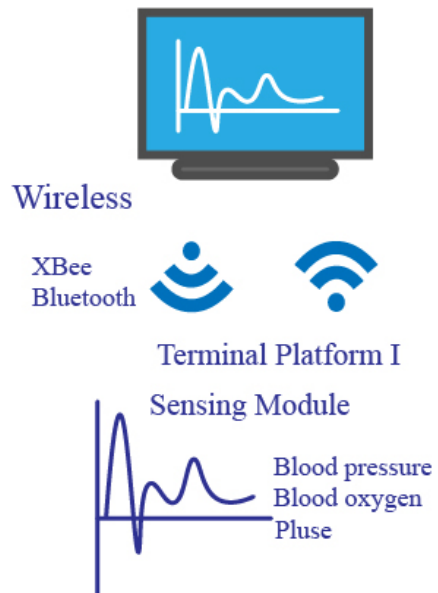

Figure 5. The structure of front-end information platform 1

Front-end information platform 1 encoding. The measured life information (such as blood oxygen) uses Xbee wireless communicator to transmit and receive data in the format shown in Table 1.

Table 1. Life information data format

life information	Data value	byte	Description
heartbeat	0x00, 0x01	1byte	0x00 means no heartbeat 0x01~ means have heartbeat
Wave	0x00~0x7F	1byte	No signal: 0x40
pulse	0x00~0xFF	1byte	0~255
blood oxygen	0x00~0x7F	1byte	below 70 is danger

In Table 2 and Table 3, after sending the command 3A00010006000007 to Coordinator from the PC, the PC will receive the returned value as the blood oxygen and pulsed sensing value.

Table 2. The command word from PC to coordinator

Start head	0x3A
Short Address	0x0001
Id	0x00
Command	0x06
Data Length	0x00
Data	Xx
Check Sum	0x07

Table 3. The command word return from coordinator to PC

Start head	0x3A
Short Address	0x0001
Id	0x00
Command	0x06
Data Length	0x04
Data	0x00 0x1D 0x6F 0x63
Check Sum	0x07

The other life information as like blood pressure's command word and data format as shown in Table 4, Table 5, Table 6.

Table 4. Blood pressure data format

life information	Data value	byte	Description
action	0x00~N	1byte	0x00 return the number of message
data		8byte	Action is 0x00: BYTE0 = the number of message
data		8byte	Action is 1 - N: B0: month B1: day B2: hour B3: minute B4: No Use B5: SYS B6: DIA B7: PULSE

Table 5. The command word from PC to coordinator

Start head	0x3A
Short Address	0x0001
Id	0x00
Command	0x07
Data Length	0x09
Data	01
Check Sum	0x0F

Table 6. The command word return from coordinator to PC

Start head	0x3A
Short Address	0x0001
Id	0x00
Command	0x07
Data Length	0x01
Data	0x01, 0x06, 0x0f, 0x0d, 0x1d, 0x00, 0x76, 0x41, 0x40,
Check Sum	0x60

2.2 Front-end Information Platform 2

Front-end information platform 2, as shown in Figure 6, the main function of the barcode optical scanner to collect the information includes patient's medical record number, clean number and clear time of endoscopic plastic tube, other data transmitted to the PC. The database is instantly displayed in the window field to achieve the effect of automated records. Compared with RFID, the use of barcode optical scanners is relatively simple, low-cost, error reduction, productivity improvement, asset management, business intelligence and signal conversion processing is relatively simple [13].
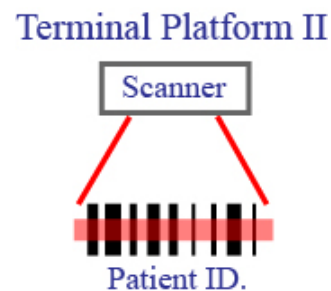

Figure 6. Front-end information platform 2

This study uses barcode scanning to identify the differences of the instruments was used. The hospital needs medical records, endoscope numbers, plastic tube numbers, washing machines, nursing staff, start time, and end time seven parameters.

The medical record number must be scanned first. If other parameters such as the number of the endoscope are scanned first, an error message will be displayed to prevent the instrument from being used but the user cannot be known until the medical record number is scanned first. When scanning gastroscopy number, start the start time, and then scan the remaining diagnostic instruments until all the instruments have been read. After scanning the endoscope, it means that the endoscope is in use. If the gastroscopy number reads different values, an error message appears. Complete reading is completed, start the end time and import the database.

2.3 Database Information System

The information system designed in this study is like the background of the web-based database. The information system adopts the XAMPP architecture (windows family or Linux + php +Apache + MySql). The information and application platform architecture is shown in Figure 7. Integrate the sensing data received by the front-end information platform 1 and 2 into the information and application platform (PC Web Edition) display window, and determine and store the various fields of the barcode scanning system (front-end information platform 2) in MY-SQL. In order to meet the needs of diversified and elastically adaptable operating environments to achieve practical records, the following describes the information application platform. The appendix fragment code describes the method of automatic serialization and linking to the database.

Figure 7. Database information system

This study uses some software tools as follow to develop the database information system platform:

(1) Microsoft Visual studio 2017: Visual studio 2017 is a web-based application that uses object-oriented development. It uses serial port components to communicate with data, and then uses OBDC (Open Database Connectivity) to connect to a database to develop database applications. Visual studio 2017 is

designed with a serial port and a database to design an automated identification system that includes two interface windows and two query forms. Used to monitor and store the read data.

(2) XAMPP (including Apache, PHP and MySQL): Many people learned from their experience that installing Apache web server is not easy, especially if you want to install MySQL, PHP, Perl, etc. It's more difficult. XAMPP is a fairly easy-to-install Apache extension that includes MySQL, PHP, and Perl. This paper will use the program form designed to monitor the information data read, stored in the database as shown in Figure 8, this software is open source, you can download on the Internet.
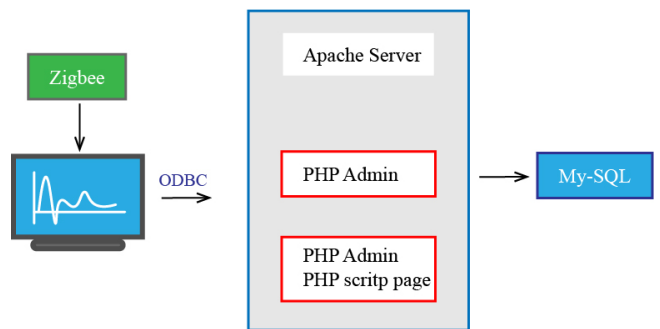

Figure 8. XAMPP style database structure

The use of serial communication is very popular in various industrial control applications, but it is almost always in the role of the user; therefore, serial communication is applied to the system of medical care automation. From the perspective of program writing, it is provided by VB2010. In the category, serial port elements are used to handle serial port control and data transmission and reception. In this paper, tandem communication acts as a link between the instrument and the interface. The data output from the hardware and the data sent by the receiver are converted into a decimal system for interpretation by the user.

3 Experimental Result

The results of the experiment, whether it is the measurement data of the patient's life information and the number of times the gastroscopy is used, the number, the cleaning process record, etc. are collected by the front-end information platform 1, 2, and the front end of the WSN network is connected. The collected data is presented on the information system's webpage and stored in the database at the back end of the webpage. Compared with the original manual operation, the original record (gastroscopy usage count and washing machine ID) will total between about 50 and 60 seconds. Networking technology automates operations, shortening the recording time to 7-10 seconds.

The patient life information like blood oxygen, Pulse,

and blood pressure was measured by terminal platform 1is necessary, and the results will on the Information Application Platform Web Page immediately. The life information result of patient not only display on screen for doctor, but store in the medical management database automatically. These data measure from front-end information platform 1 is displayed on information system webpage (server).

In the front-end information platform 2, the optical scanner collects data such as the usage count of gastroscopy was used, the gastroscopy using start/end time, the washing machine ID number, and the user. All relevant records are show on the information system too.

Web database. The contents of this study web-based database as shown in Figure 9. The webpage window is written in PHP, the database content data is provided, the date query is provided, and the medical record number is queried. The display content is the start time of the gastroscopy and various parameters are convenient for doctors to refer to. If the data is too long, the SCV file can be created and opened by EXCEL for easy interpretation.

Figure 9. Front page of database screen

4 Conclusion

With the development of various biomedical sensing technologies and the integration of the Internet, the management of medical care systems through the Internet and the real-time monitoring of vital signals are the focus of development, each time using the diagnosis and treatment equipment and monitoring system to the Internet The road is transmitted to the diagnostic database system to detect the disease changes of the medical instruments and vital signs used by the doctors and to be properly placed. The field investigation results currently lack a management system for the medical instruments in the hospital, and the electronic communication technology of Taiwan is used. And create advantages, enough to become the leader of the future home care industry.

In this study, a medical care automation system was established to complete the life information, automatic measurement of clean and clean soaking and re-use of the gastroscopy identification system, whether it is the mastery of life information before and after surgery, and the sense of urine volume in the hospital bed. It measures the complete system integration of embedded systems, wireless communication, and database management system technology, providing patients with comfortable medical care, and providing good quality of care.

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Biographies

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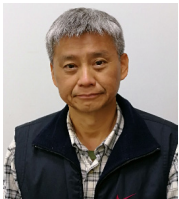
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