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WIRELESS MEDICAL CARE BASED ON RFID POSITIONING SYSTEM

Wen-Tsai SUNG[1*], Kuan-Cheng DAI[1], Chung-Yen HSIAO[1] and Chun-Wei SUNG[2]

[1]Department of Electrical Engineering, National Chin-Yi University of Technology, Taichung City, Taiwan
[2]Department of Industrial Technology Education, National Kaohsiung Normal University, Kaohsiung, Taiwan

Abstract

More attention is now being paid to patient safety and medical quality improvement. This paper will establish a set of wireless medical care systems for medical care environment simulation. The RFID positioning system permits medical staff to always observe patient's health and location positioning. If a sudden emergency situation should occur, medical staff can arrive in time to solve the medical problems.

Keywords: *wireless, medical care, active RFID, positioning*

Introduction

More attention is given to hospital patient safety and medical quality improvement. In recent years many medical applications have developed related to RFID. For example, domestic Cathay General hospital uses active RFID control in the operating room to improve medical care efficiency and reduce medical errors. RFID can be used for positioning in addition to reading and writing related data.

This study combines medical care with RFID targeting. An RFID system can monitor the patient's status at any time using wireless WIFI module instantaneous transmission signals connected to the host. RFID patient location positioning can send care workers to the patient's location if any emergency occurs at any time. On demand first aid is provided in record time.

System architecture

The system architecture presented in this study is divided into four parts, physiological signal acquisition module, wireless transmission module, RFID positioning device and data processing display device. As shown in Fig. 1.

The physiological signal capture module uses the DSPIC30F4011 as the main control center (Fig. 2). This center has a heart rate module, blood pressure module, respiration rate module, body temperature module and blood oxygen saturation module. When the physiological signal is retrieved, it will be sent to the data processing display device via the Wi-Fi transmission module.

The RFID reader reads the Active RFID TAG then processes the data through the RS232 signal to the data processing display device, and displays patient positioning in the monitoring interface.

The above system architecture monitoring interface monitors the patient's physiological data, and location at all times to capture sudden emergency situations, and immediately dispatch the correct first aid function.

Physiological signal capture

Five different physiological signal interception modules are included. A heart rate module, blood pressure module, respiration rate and body temperature module and blood oxygen saturation

Corresponding author: songchen@ncut.edu.tw

module are included. They use the DSPIC30F4011 as the main control center. The data is intercepted through the Wi-Fi transmission module to the data processing display device.

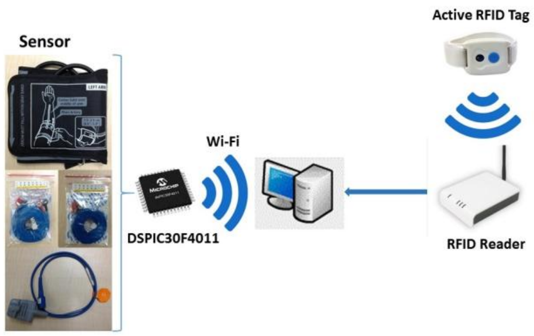

Fig. 1. System architecture

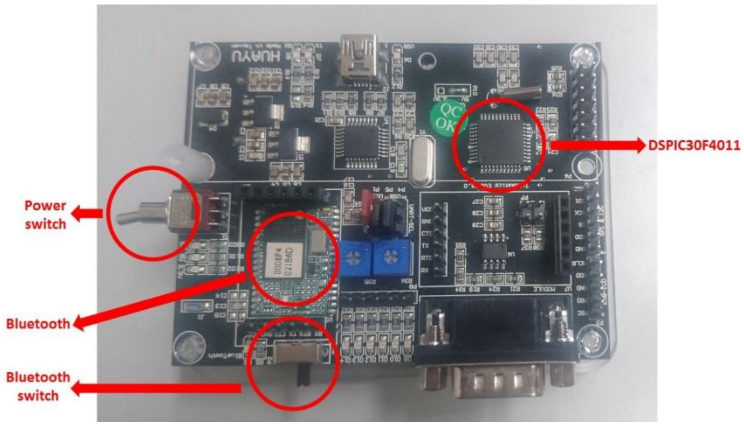

Fig. 2. DSPIC30F4011 development board

Physiological signal capture

Five different physiological signal interception modules are included. A heart rate module, blood pressure module, respiration rate and body temperature module and blood oxygen saturation module are included. They use the DSPIC30F4011 as the main control center. The data is intercepted through the Wi-Fi transmission module to the data processing display device.

Heart rate module

The heart rate module, as shown in Fig. 3 and 4, can detect the electrocardiogram.

Electrocardiography (ECG) is the process of recording the heart's electrical activity over a period of time using electrodes placed on the skin. These electrodes detect the tiny electrical changes on the skin that arise from the heart muscle's electrophysiologic pattern of depolarizing and repolarizing during each heartbeat. This is a very commonly performed cardiology test.

Blood oxygen saturation module

Oxygen saturation is a term referring to the fraction of oxygen-saturated hemoglobin relative to total hemoglobin (unsaturated + saturated) in the blood.

The device uses light-emitting diodes in conjunction with a light-sensitive sensor to measure the absorption of red and infrared light in the extremity. The difference in absorption between oxygenated and deoxygenated hemoglobin makes the calculation possible. As shown in Fig. 5.

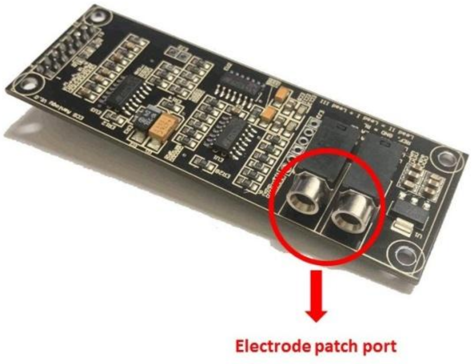

Fig. 3. Heart rate module

Fig. 4. ECG wire and electrode patch

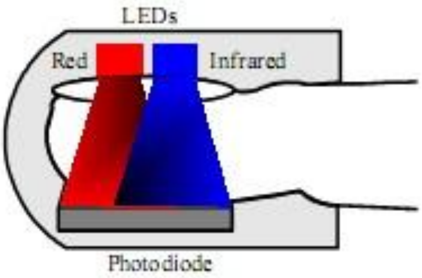

Fig. 5. SpO2 sensor structure

The blood oxygen saturation module is shown in Fig. 6 and 7.

Blood pressure module

The blood pressure measurement method used in this module is the oscillation method. The instrument will first inflate to crush the artery completely to stop the blood flow. The pressure is then slowly relieved while the sensitive pressure sensor reads the pulse above the vein pulse. Pressure is continually slowly discharged while the Pulse pressure gradually becomes stronger.

Experiments show that when the pressure inside the cuff is equal to the average pressure, the pressure in the cuff is the largest. The pressure in the cuff is then reduced and the intravascular obstruction is reduced while the jetting effect becomes gradually smaller. Until the cuff pressure is less than the diastolic pressure pulsation cannot be produced.

The experimental results show that the pressure in the bag is equal to the average pressure of the artery. The maximum amplitude is then the center. When the vibration amplitude is about 50% of the maximum amplitude, the cuff internal pressure is about the same as the systolic blood pressure. The maximum amplitude is then the center back to find the vibration wave at about 80% of the maximum amplitude. The pressure inside the cuff is equivalent to the diastolic pressure as shown in Fig. 8.

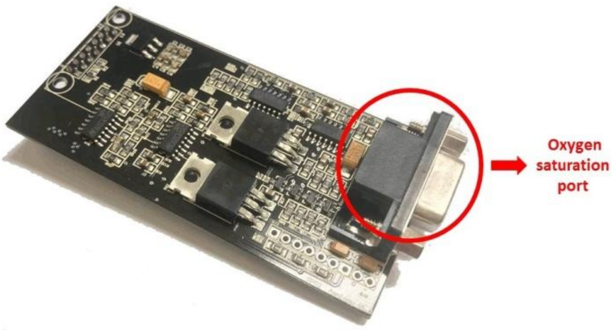

Fig. 6. Blood oxygen saturation module

Fig. 7. SpO2 sensor

Because the oscillation method measures a series of pulsations and finds the maximum amplitude, the maximum amplitude of 0.5 and 0.8 were set as the systolic and diastolic blood pressure.

So it is not affected by the heart rate and vascular impedance, this is the only way to simultaneously measure systolic, diastolic and mean pressures in a noninvasive sphygmomanometer. Therefore, the modern automatic non-invasive sphygmomanometer uses this method.

The blood pressure module developed in this study is shown in Fig. 9 and 10.

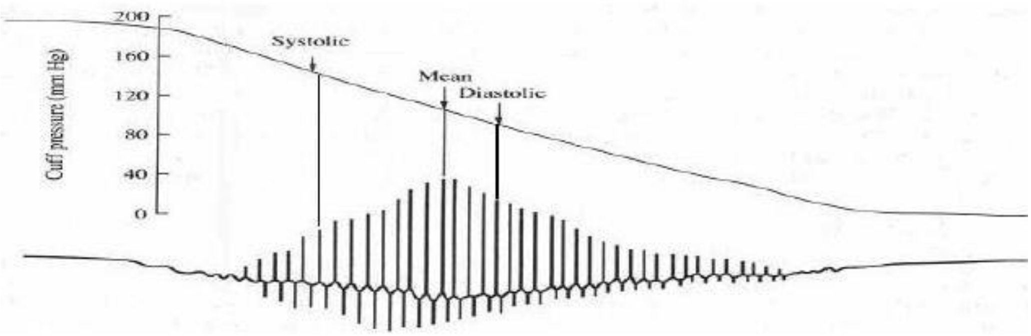

Fig. 8. Blood pressure waveform

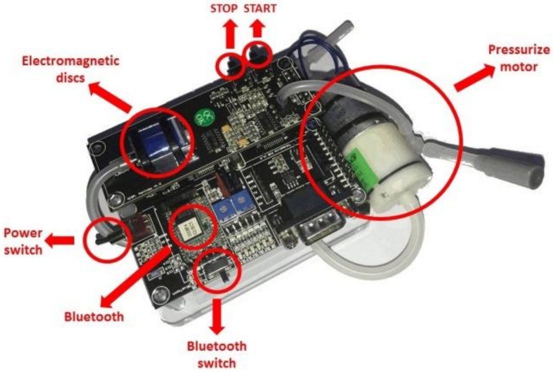

Fig. 9. Blood pressure module

Fig. 10. Blood pressure arm band

Respiration rate and body temperature module

Respiratory rate measurement regards the air as DC insulator, so the human body lungs act like a variable capacitor, with inspiratory and expiratory changes in capacitance, inspiratory capacitance increases, and exhalation when the capacitance value decreases. The rest of the body can be regarded as resistance to the chest.

Fig. 11 represents a simple cross-chest impedance model between two points. Where RA RB and RC represent the resistance of the general human tissue, and RL and CL represent the lung impedance. In Fig. 11 (a) can be reduced to (b).

When adding a small alternating current at a known frequency between two points of the thoracic cavity, the impedance change in the lungs with respect to respiration can be calculated. This principle is called "Impedance Pneumography".

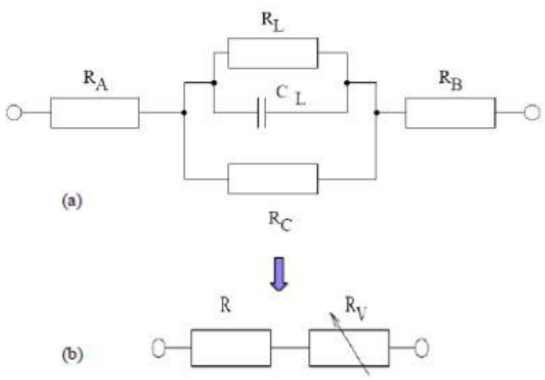

Fig. 11. Respiration rate sensing principle

We can therefore measure the respiration rate using this principle. The respiration rate and body temperature module is shown in Fig. 12 and 13.

Fig. 121. Respiration rate and body temperature module

RFID positioning

RFID

Radio-frequency identification (RFID) uses electromagnetic fields to automatically identify and track tags attached to objects. The tags contain electronically stored information. Passive tags collect energy from a nearby RFID reader's interrogating radio waves. Active tags have a local power source such as a battery and may operate at hundreds of meters from the RFID reader. Unlike a barcode, the tag need not be within the line of sight of the reader, so it may be embedded inside a tracked object.

This study uses active RFID wristbands and active RFID readers as positioning devices, as shown in Fig. 14 and 15.

Fig. 13. Wire and electrode patch

Fig. 14. Active RFID wristband

Fig. 15. Active RFID reader

RSSI

Received signal strength indicator (RSSI) can be used to measure the distance between the transmitter and the receiver. The RSSI value of the receiver received RF energy intensity, the transmitter in the send signal to the receiving end of the process, RF energy will be lost.

The degree of loss is proportional to the distance between the transmitter and the receiver, whereby we can use RSSI to calculate the distance between the transmitter and the receiver.The RSSI value is inversely proportional to the distance. The higher the RSSI the stronger the signal and the closer the distance. Thus, when the RSSI value is expressed in a negative form (for example, -

100), the closer the value is to 0, the stronger the received signal.， The relationship between signal strength and distance is shown in Fig. 16.

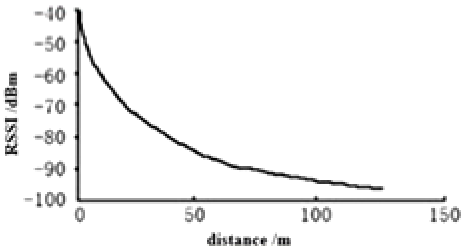

Fig. 16. Signal strength and distance relationship diagram

Equation (1) can represent the relationship between RSSI and distance:

$$P_r(d) = P_r(d_0) - 10n\log\frac{d}{d_0} + X \text{ (dBm)} \tag{1}$$

In Equation (1)， d represents the distance between the transmitter and the receiver. The d_0 is the reference distance. $P_r(d_0)$ is the energy received by the reference distance d_0. X (dBm) shows a Gaussian distribution variable with an average value of zero. The n is called a signal propagation constant in an environmental relationship. In practice, it is generally simplified as Equation (2):

$$P_r(d) = P_r(d_0) - 10n\log\frac{d}{d_0} \tag{2}$$

In Equation (2), set to 1 meter as the reference distance, and then simplified to Equation (3):

$$RSSI = A - 10n\log(d) \tag{3}$$

In Equation (3), A is 1 meter of transmission power consumption (dBm).

Round intersection positioning

The RSSI is measured using three active coordinates of the known RFID reader. The distance d from the three readers to the RFID tag is calculated using formula (3) to three readers from the center, d for the radius of the circle. The coordinates of the intersection point D are the coordinates of the RFID tag, are shown in Fig. 17.

D point coordinates can be calculated using Equation (4):

$$\begin{cases} d1 = \sqrt{(x-x_1)^2 + (y-y_1)^2} \\ d2 = \sqrt{(x-x_2)^2 + (y-y_2)^2} \\ d3 = \sqrt{(x-x_3)^2 + (y-y_3)^2} \end{cases} \tag{4}$$

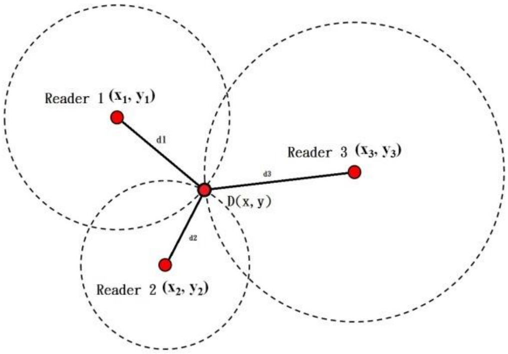

Fig. 172. Round intersection point positioning diagram

System flow chart

The system flow is shown in Fig. 18.

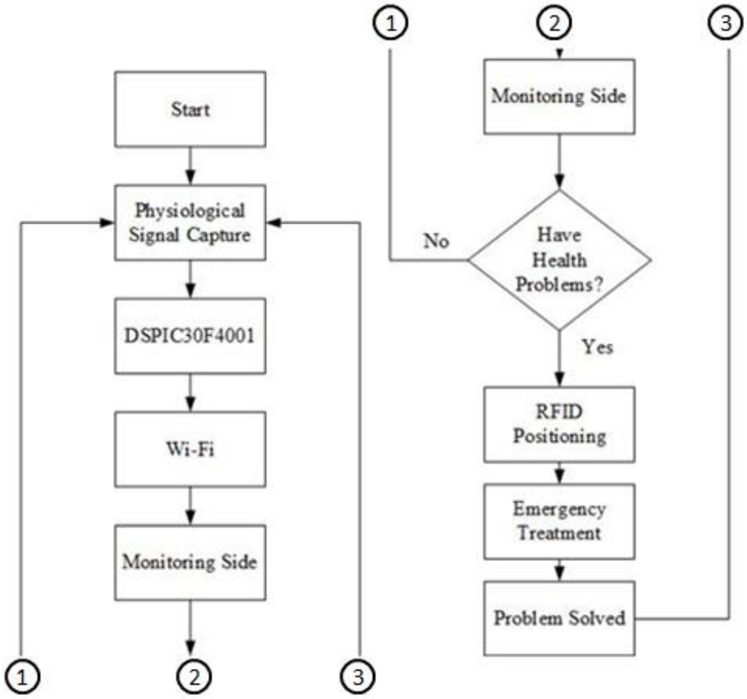

Fig. 18. System flow chart

Experimental results

The physiological signal capture module intercepts the physiological signal. DSPIC30F4011 is the main control center through the wireless WIFI to the data analysis display interface, as shown in Fig. 19.

Using a classroom as an RFID positioning analog location, active RFID signals are sent to the classroom around the RFID reader, RS232 to send the signal to the data analysis display device. The monitor after receiving the data to RSSI algorithm and circle the intersection point method analyzes the coordinates and displays it on the interface, as shown in Fig. 22.

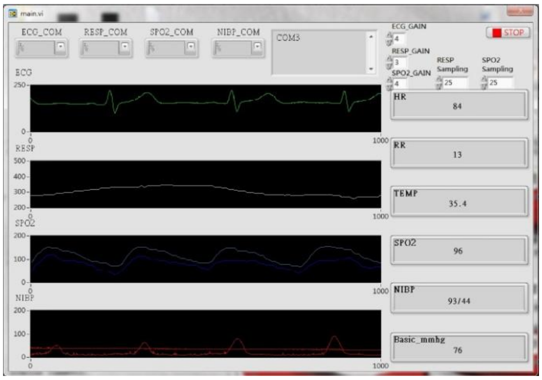

Fig. 19. Health monitoring interface

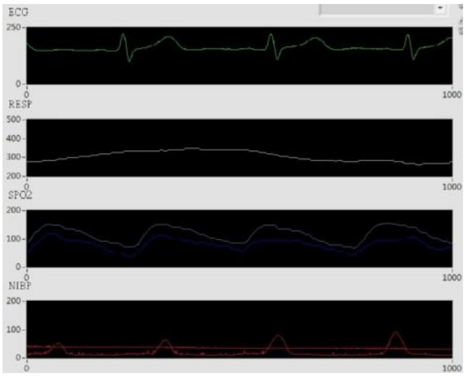

Fig. 20. Health data waveform

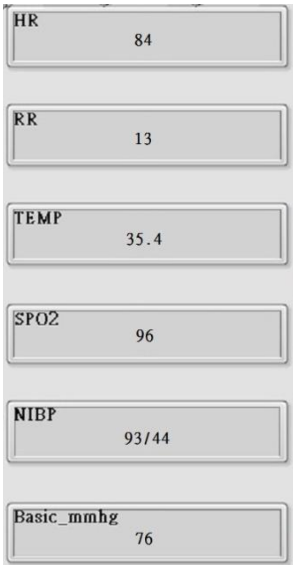

Fig. 21. Health data

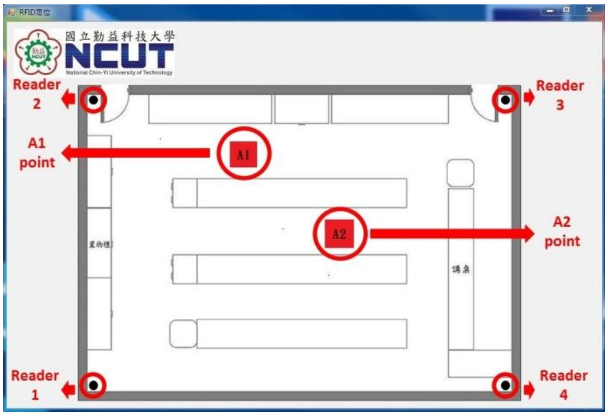

Fig. 22. Experimental positioning results

Assume that the Reader 1 coordinates are (0,0). One unit is one meter. Thus, after several experiments, Table 1 was obtained.

From Table 1 we can see RFID positioning within 1 meter of the error. But this does not affect the medical staff in the shortest possible time to find the patient.

Table 1. Calculate coordinates and actual coordinates

Calculate Coordinates(x,y)	Actual Coordinates(x,y)	Error (m)
A1(6.1,5.8)	A1(6,5)	0.80
A2(6.8,4.5)	A2(7,4)	0.53
A3(12.9,2.6)	A3(12,3)	0.98
A4(8.3,4.6)	A4(8,5)	0.67
A5(5.8,3.9)	A5(6.5,3.5)	0.80

From Fig. 19, you can clearly evaluate the patient's health, in the event of a sudden emergency situation the medical staff can quickly find the patient location through Fig. 22, to achieve immediate rescue.

Conclusion

The results show that medical staff can monitor the physical condition of patients through the health monitoring interface. If an emergency situation arises staff can also know the location of the patient through the RFID, so that the medical staff can reach the patient's location in time to rescue the patient.

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