Design of Multi-functional Physiological Signal Acquisition and Wireless Transmission System

Xue-fei WU, Zhi WENG*, Run-jing ZHOU, Jian-ting AO, Xiang-ru REN, Bu-er SHUN and Hui-yu ZHU
College of Electronic Information Engineering, Inner Mongolia University, Hohhot 010021, China
*Corresponding author

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Abstract. The design is based on the ultra-low power microcontroller MSP430. It is designed and developed to measure the temperature and heart rate pulse and blood flow velocity by using temperature sensor, ultrasonic module, heart rate pulse detection sensor, global satellite positioning module, global mobile communication system and wireless transmission module. Anti-lost wireless transmission system. The terminal through the positioning system, the temperature sensor pulse detection sensor and the ultrasonic module to obtain the location information and physical health of the elderly, and then in the form of short messages sent to the GSM through the SMS to receive the phone terminal, to achieve the location of the elderly and their physical condition more comprehensive Real-time monitoring, but also through the Bluetooth data upload to the database, to achieve the data storage and analysis.

Introduction

It is estimated that by 2020, the number of elderly people over 60 years old will increase to about 255 million, accounting for 17.8% of the total population, will enter the aging society, with the aging society, the elderly lost and the elderly physical condition. Throughout the domestic and international electronic anti-lost equipment, the principle is different. In 2004, the United States developed a called “star table” device, can determine the exact location. In 2005, France launched a “COLOMBA” anti-lost phone bracelet, the use of GPS satellite positioning system for patients with Alzheimer's disease to help [1]. Some designs utilize fabric type ECG electrodes and three-dimensional acceleration sensors, and support Bluetooth wireless communication. When the monitoring terminal detects the heart rate abnormality or fall of the elderly, it will realize the alarm through wireless Bluetooth technology, implement timely rescue, and avoid accidental occurrence [2].

At the same time, the market sells every kind of the anti-lost heart rate detection Bracelet, Such as millet bracelet and so on. However, most of them are designed for young people; they also need Bluetooth system supports. For the elderly, Convenient and simpler than the heart rate pulse and heart rate pulse slower than the young and accurate algorithms and other body conditions such as body temperature, blood flow and other physical conditions monitoring real-time monitoring system is not yet perfect. This article will carry out a detailed study of these issues one by one.

Design of the Overall System

The system consists of MSP430 single-chip microcomputer, heart rate pulse measurement of the photoelectric reflective analog sensor, ultrasonic, human body temperature sensor, the global satellite positioning module, the global mobile communication system module and wireless transmission module seven parts, as shown in Figure 1.

The positioning module collects and positions information. The CPU central processor receives the information. Then the location information is sent to the specified information on the phone number through the GSM short message functions. Heart rate pulse detection sensor monitors the pulse information and body temperature of the elderly in real time, when the pulse and body temperature
close to the dangerous value, through the GSM short message function send information, send to the receiving information mobile phone number in time to remind the guardian, monitor the blood speed of the elderly in real time. At this point, to achieve real-time monitoring and positioning of the health status and location of the elderly. If the elderly wears a mobile phone or home use, you can also temperature value and heart rate pulse value to the computer, to achieve data storage and data analysis, in order to understand the physical condition of the elderly.

The MSP430 is a 16-bit ultra-low power microcontroller manufactured by Texas Instruments \[3\]. SIM868 module is selected in the communication module for its high performance and integration. SON1205 sensor is used in heart rate pulse detection module. CJMCU-614 temperature measurement module is temperature sensor module \[4\]. CD4052 is a differential 4-channel digital control analog switch \[5\]. ZigBee technology is used in wireless transmission module.

**Design of the System Hardware and Software**

MSP430 as the core, the microcontroller UCA0TXD and UCA0RXD connected to the CD4052’s common output and input, the other channel access SIM868 module on the pin and body temperature sensor. The reserved location of SIM868 terminates the UCA1TXD0 and UCA1RXD0 of the one-chip computer. Heart rate pulse sensor output square wave, we count the square wave signal. When receiving the signal, the output is connected with the microcontroller I / O port. The ultrasonic output is also connected with the microcontroller I / O port, the microcontroller for computing. Hardware physical map is shown in Figure 2. Software flow chart is shown in Figure 3.
### Algorithms in Software Design

#### Numerical Processing in Heart Rate and Pulse Measurement

The heart rate pulse sensor used by the microcontroller I/O port is defined as the input pin P1DIR = 0x00, with an external interrupt, edge triggered, every time the interrupt is sensed to sensornum add 1. I/O function is multiplexed as a serial input and output. Define Pulse as the pulse heart rate value; sensornum is the number of pulses to detect heart rate pulse transitions. Elderly heart rate pulse value normal range is 55-90 times / min in the design.

The four algorithms listed in Table 1 are within normal values, normal values to tachycardia, and heart rate values calculated from normal values to bradycardia.

After a comparative analysis, when the elderly in a certain degree of exercise to increase the value of heart rate pulse, in order to make it wrong alarm and no delay alarm, so set the alarm line at 90 beats / min. The conclusion is that when the tachycardia (greater than 120 beats / minute) can be an alarm, after the calculation of the four algorithms, the use of a mean square is more secure. The reason is that it can immediately reach the alarm range of 90 times / minute after calculation. Slower arrhythmia (less than 40 beats / min), when we use the harmonic mean to calculate a lower heart rate value, the system immediately reaches the alarm range (55 beats / min). When the heart rate pulse is within the normal range, we use the geometric mean algorithm.
Table 1. Calculated values for the four algorithms.

<table>
<thead>
<tr>
<th>Heart Rate</th>
<th>Algorithm</th>
<th>Arithmetic mean</th>
<th>Square mean</th>
<th>Harmonic average</th>
<th>Geometric mean</th>
</tr>
</thead>
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<td>60/65</td>
<td></td>
<td>62.50</td>
<td>62.55</td>
<td>62.40</td>
<td>62.45</td>
</tr>
<tr>
<td>55/120</td>
<td></td>
<td>87.50</td>
<td>93.34</td>
<td>64.11</td>
<td>81.24</td>
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<tr>
<td>60/120</td>
<td></td>
<td>90.00</td>
<td>94.87</td>
<td>80.00</td>
<td>84.85</td>
</tr>
<tr>
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<td>96.50</td>
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<td>95.00</td>
<td>98.23</td>
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</tr>
<tr>
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<td>63.26</td>
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<tr>
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<td></td>
<td>47.50</td>
<td>48.09</td>
<td>46.32</td>
<td>46.90</td>
</tr>
</tbody>
</table>

Ultrasonic Measurement of Blood Flow

As long as blood flow velocity can be measured, it is possible to diagnose valvular heart disease and congenital heart malformations caused by abnormal blood flow such as reverse flow, stenosis flow or short-circuit flow in blood vessels or to diagnose peripheral vascular stenosis and occlusion of the carotid artery and extremity arteries Lesions and determine the severity [6].

**Option 1: Measure the Blood Flow Rate Using the Time Difference Method**

The principle is to use a pair of ultrasonic energy to alternately send and receive ultrasonic waves, the ultrasonic wave in the downstream fast, slow propagation in the counter-current, the time difference between the received can be considered the speed of blood. Set the first time from the ultrasonic emission to the receiving time is \( \Delta t_1 \), after receiving the echo signal and then send an ultrasonic signal, the second transceiver interval is \( \Delta t_2 \). The first time the ultrasonic signal arrives at the object, the distance between the transmitting probe and the object is \( S_1 \), When the second ultrasonic signal arrives at the object, the distance between the transmitting probe and the object is \( S_2 \), the moving speed of the object [7]:

\[
V = \frac{(S_1 - S_2)}{\Delta t_1 + \Delta t_2}
\]  

(1)

**Option 2: Doppler Effect**

The principle is the ultrasonic wave velocity generated by the probe, into the blood vessels through the skin, encounter blood cells after scattering, the scattering of the return direction of the scattering wave is received by the probe. The system can calculate the blood flow rate based on the Doppler shift of the outgoing and reflected waves. Doppler flow meter, for example, ultrasonic probe to the angle of \( \theta \), the frequency \( f_p \) emits ultrasound to the blood vessel, ultrasound in the human body to spread the speed of \( u_p \). Wave source still, in the direction of the wave of blood cells to \( u_p \cos \theta \) away from the wave source, the blood cells received the frequency is \( \frac{u - u_p \cos \theta}{u} f_c \). Blood cells are then reflected at the frequency of \( \frac{u - u_p \cos \theta}{u} f_c \) to the ultrasound probe. Wave source (blood cell) in the direction of wave propagation to \( u_p \cos \theta \) away from the receiver, the receiver is still, the ultrasonic probe received frequency:

\[
f_f = \frac{u - u_p \cos \theta}{u + u_p \cos \theta} f_c
\]  

(2)

Doppler shift:
\[ f_r - f_c = \frac{2u \cos \theta}{u} f_c \]  

(3)

That is the basic formula of ultrasonic velocity measurement \([8]\).

**Data Transmission**

DL-20 ZigBee, is divided into A-side and B-side through point-to-point mode of operation. A side of the wireless transmission of data is transmitted to the B-side. Realize the data transmission between one-chip computer and apparatus. This section of ZigBee in the open area within the visible transmission distance of 250 meters, point-to-point error bit rate of 0.00%. Two ZigBee master-slave modes, when their channels set the same channel, they can transfer data. Data transfer between ZigBee, the data can be displayed on the computer's serial debugging assistant.

**Summary**

The terminal is based on MSP430 microcontroller. System to achieve a wireless measurement of body temperature and heart rate heart rate anti-loss system and can achieve wireless transmission design. The system uses 5V power supply and low-power long-term stable operation. Its positioning accuracy is high, and the physical condition of the elderly is more comprehensively examined from the body temperature heart rate pulse and the blood flow rate. At the same time, each module and chip size is small. It is suitable for portable devices, and the performance to achieve the design goals.

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**References**


