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Research of Wireless Transmission Based on Pulse Signal

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Abstract. The system uses dual MCU design to achieve the acquisition and transmission of pulse signal without affecting the user's sleeping process. The pulse signal is collected by infrared pulse sensor, and is wireless transferred to the personal computer by JF24C after the process of amplification, baseline correction and so on. Then personal computer analyses the signal using the method of wavelet transform algorithm. With wavelet decomposition, pulse signal can be decomposed into different scales of wavelet coefficients and recomposed according to the low-frequency coefficient of the bottom and high-frequency coefficients of various layers. During the process of wave recomposition , the coefficients related to noise can be rejected while the valuable information in the pulse signal maintained, and all the processes achieve the restoration of pulse signal. What is more, after simulating the wavelet transform algorithm using MATLAB, the consequences of this simulation indicate that multiple interferences can be effectively suppressed while keeping the pulse signal undistorted and it sustains the relevant characteristics of pulse signal.

Introduction

Sleep Medicine has become an emerging interdisciplinary in medicine. How to effective monitoring sleep condition of the sick population and win time for the timely ambulance is a hot topic in the study of monitoring sleep condition of the sick population, and win time for the timely Sleep Medicine. Traditional sleep condition of the sick population, and win time for the timely Sleep Medicine. Traditional sleep monitoring equipment and methods, such as the sleep monitor based on multiple physiological signals, classic entire computer paperless recorder, dynamic EEG monitoring system and so on, using the electrode patches or camera monitoring means, inevitably causing interference to the sleeper, thereby affecting its physical condition. Therefore, how to get to be monitored by physiological signals while does no affect to the Monitored person, s normal sleep concerns by many experts and scholars.

The pulse is a common physiological phenomenon, an external reflection of the heart and vascular status and other important information. Pulse measuring not only for blood pressure, blood flow and other physiological detection of physiological and reference information, but also gives many the diagnostic valuable diagnostic information. With the development of science and technology, objective and quantitative pulse diagnosis has become the inevitable trend of TCM diagnosis. The development of the embedded technology provides a solution for the problem[1-2].

System Design

The system consists of collecting conditioning modules embedded pulse signal transmission module and the PC terminal monitoring modules.

Using embedded technology, in the case of does not interfere with sleep, using wireless technology, design dual MCU system. ARM7 family of 32-bit micro-controller chip LPC2103 is used as MCU. It has two 32-bit, two 16-bit timers and an improved 10-bit ADC, LQFP48 package, very small size, low power consumption, very suitable for miniaturized low-power requirements as the main application[3-4].

Wavelet Transform

The basic meaning of Wavelet transform[5] is as follows: Make a shift τ for a basic wavelet function $\psi(t)$, then under different scales a, do inner product between it and signal $x(t)$

$$WT_x(a,\tau) = \frac{1}{\sqrt{a}} \int_{-\infty}^{+\infty} x(t)\psi^*(\frac{t-\tau}{a})dt \quad \mathrm{a} > 0 \tag{1}$$

The equivalent frequency representation is:

$$WT_x(a,\tau) = \frac{\sqrt{a}}{\sqrt{2\pi}} \int_{-\infty}^{+\infty} X(\omega)\psi^*(a\omega)e^{j\omega\tau}d\omega \tag{2}$$

Where $\psi(\omega)$ and $x(\omega)$ are the Fourier transform of $\psi(t)$ and $x(t)$.

Wavelet transform has the following characteristics and functions:

We regard wavelet transform as a band-pass filter with fundamental frequency $\psi(\omega)$, which filter signal under different scales a. In other words, its relative bandwidth (the ratio of Bandwidth and center frequency) is constant.

Make an appropriate choice for basic wavelet, then make sure that $\psi(t)$ is limited support in the time domain and $\psi(\omega)$ is more centered in the frequency domain. Therefore, wavelet transform has the capability of showing signal's local characteristic in the time and frequency domain, these characteristics is good for the detection for the transient state or singular point of signal.

Wavelet transform has the characteristic of multi-resolution (multi-scale), which can observe signal from thick to thin gradual.

The space is decomposed into a group of step including subspaces step by step:

$$V_0 = V_1 \oplus W_1 \ , V_1 = V_2 \oplus W_2, \ldots, V_j = V_{j+1} \oplus W_{j+1}, \cdots \tag{3}$$

Where j is an integer from $-\infty$ to $+\infty$. The small the j is, the bigger the space, the following diagram is the decomposition schematic diagram

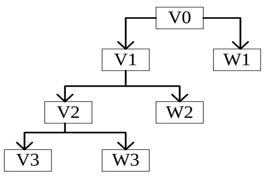

Fig. 1 Multi-resolution decomposition schematic diagram

For a function $f(x) \in V_0$, we can decompose it into detail part W1 and large scale part V1, and V1 can be further decomposition. If $d_{j,k}$ is the j-th wavelet coefficient and $c_{j,k}$ is the j-th residual coefficient, so the decomposition algorithms are as follows:

$$d_{j,k} = \sum_m g_{m-2k} c_{j-1,m} \tag{4}$$

$$c_{j,k} = \sum_m h_{m-2k} c_{j-1,m} \tag{5}$$

The matching reconstruction algorithms[6] is:

$$c_{j-1,m} = \sum_k h_{m-2k} c_{j,k} + \sum_k g_{m-2k} d_{j,k} \tag{6}$$

Where $g_n = (-1)^n h_{-n+1}$.

Hardware System Design

4.1 Signal acquisition module

Pulse acquisition circuit including the pulse signal acquisition and signal preprocessing.

4.1.1 Signal Acquisition

Pulse sensor select HKG-07 series which has the advantages of small volume, low power consumption, high sensitivity and anti-interference ability. It detects the tip of the finger micro blood volume change caused by heart beat. To realize pulse signal collection, choose comfortable, stable appearance and wear method, the design becomes small close-fitting refers to the model. To realize pulse signal acquisition, designed to be compact and close to finger type, and select comfort, solid appearance and wearing method.

4.1.2 Signal Processing

The pulse frequency of the signal is usually between 0.2 to 45 Hz, which is a weak non-physiological ultra-low-frequency signal .Its effective frequency of the harmonic component is 40Hz or less. As a result, pulse signal easily introduced frequency interference[7].

At the same time, during the pulse signal acquisition process, pulse signal is susceptible affected by noise such as the baseline drift, human activities, the EMG interference, noise from the sensor and other factors. Therefore, the collected pulse signal must pass a signal processing.

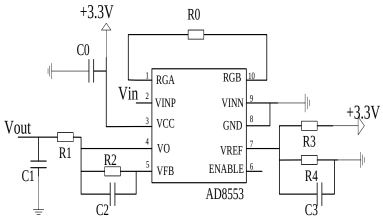

Fig. 2 Amplifier circuit

Amplifying circuit is necessary because pulse sensor output voltage amplitude is 0.2 ~ 1 V, and conversion need voltage range in 0 ~ 3.3 V. AD8553 is a precision instrumentation amplifier with low offset, low drift and high common-mode rejection characteristics, developed by the AD company.AD8553 is very suitable for amplifying circuit design requirements because of the characteristics of working voltage range 1.8 V to 5.5 V, offset voltage for twenty μ V, offset voltage drift for 0.1 u V / ℃,and the voltage noise was only 0.7 mV. And the small size and low cost make this device suitable for large scale application.

Amplifier circuit as shown in Figure 2, its gains as the formula (7) below, the gain of the circuit:

$$G = 2 \times (\frac{R1}{R0}) \tag{7}$$

Signal preprocessing circuit also includes baseline calibration circuits, 50 Hz notch filter, band-pass filter 0.2~45Hz and a/d conversion circuit. After the above procedure, the signal is transmitted to the wireless communication modules and ready to be sent.

4.2 Wireless communication module

To not affect the sleeper who is being monitored, JF24C is used for wireless communication to complete the transmission of pulse signal. JF24C frequency is 2.4GHz, with high-frequency keying transceiver circuit function, and it contains the FIFO, to reduce the burden on micro-controllers in the data processing; The capabilities such as transfer rates up to 1Mbps, fast frequency hopping, forward error correction and cyclic redundancy check function, make sure it can achieve reliable data transmission in the crowded ISM frequency band.

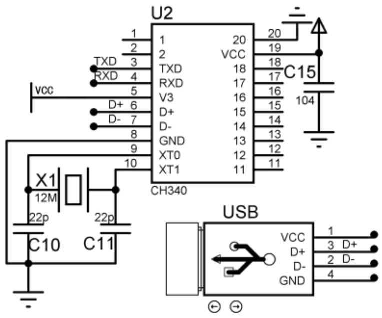

Fig. 3 Serial to USB circuit

USB data bus has now gained popularity on various computers, becoming the standard for computer equipment. As with the advantages of universal, high-speed, hot-plug USB interface and Plug-and-play, it is very suitable for application in the field of data acquisition. For convenience, USB is used between LPC2103 and Computer, and CH340 is used to complete the transfer between Serial ports and Parallel port[8]. Finger 3 shows the switching circuit.

Software System Design

5.1 Embedded system software design

The implement of system software includes embedded terminal and PC terminal.

The development of system embedded program used the Keil IDE and C language debugger. Signal acquisition and wireless transmitter pulse signal is sent to LPC2103 by the built-in A/D conversion, LPC2103 needs to wireless transmitter and determines whether transmissions completed. Wireless reception LPC2103 controls the wireless receiver module receives data and determines whether or not reception is completed, as shown in Fig.4.

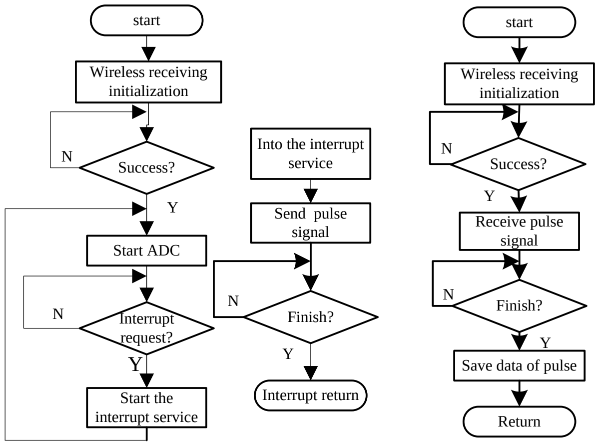

Fig 4 Wireless transmission (left) and a wireless receiver (right) flow chart

5.2 PC terminal software design

For the realization of the received pulse signal denoising and displaying functions, the PC terminal software take full advantage of MATLAB programming language's feature，like high efficiency, interactive, portability, efficient and convenient matrix and array operations, convenient drawing function, hybrid Programmed with visual Basic 6.0, Combined MATLAB powerful computing capabilities with visual Basic 6.0 advantage in the development of the graphical user interface to design a pulse signal processing visualization software for the pulse signal processing an effective solution to achieve seamless integration of application systems.

In order to achieve system integration, a mixture of Visual Basic 6.0 and MATLAB programming method is used here. Methods of a mixture of the two programming as following: with ActiveX components, with the DDE technology, the M-file conversion, references MatrixVB plug. By comparison, the latter two methods can ensure the portability of the system, so that the system can be used without MATLAB environment.

Simulation Analysis

In order to verify the effect of wavelet denoising, this paper used MTALAB fitting way to generate pulse waveforms and selected wavelet function db5 to decomposed pulse signal by a variety of noise pollution into 8 layers. The simulation result shows in Figure 5. From the results of the simulation, the method is able to maintain the pulse signal undistorted to case effectively inhibit EMG interference, frequency interference, noise, while maintaining the pulse of the relevant characteristics remaining unchanged.

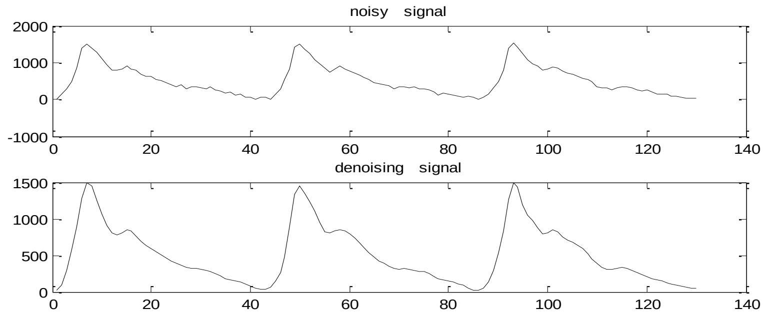

Fig 5 The diagram of simulation results

Conclusions

This paper has used embedded technology to build systems platform and monitored its pulse wave acquisition unperturbed normal sleep by wireless communication technology, As pulse signals are susceptible to frequency interference, EMG interference, baseline drift, human activities sensor noise exposure and other factors, this paper has used MATLAB software and based on principle of the wavelet transform to implement signal denoising. From the simulation results, using wavelet transform can effectively suppress noise while retaining characteristics of the pulse signal; Pulse signal can be effective monitored by PC platform mixed programming of MATLAB and Visual Basic 6.0. It has a good practical application value.

Acknowledgments

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