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Development of Unbound Sleep Monitoring Air Cushion

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Abstract

Sleep quality is one of the key factors affecting physical health. This paper discusses the methods and evaluation of sleep monitoring. Using an unconstrained portable air cushion as a new means of monitoring sleep status, the long-term, non-invasive and natural sleep monitoring of the dynamic sleep monitoring system was realized. The respiratory signals during sleep were collected and processed, and compared with the monitoring results of the ' gold standard for sleep monitoring ' polysomnography. The sleep monitoring equipment designed in this study has important engineering application value and can provide a basis for doctors to guide sleep rehabilitation or disease information mining.

Keywords

Intelligent sleep Monitoring; LabView PC monitoring softwar; Time-frequency analysis; Sleep Apnea detection.

1. Introduction

Sleep is an important part of restoring physical fitness and maintaining health. Long-term low sleep quality can lead to respiratory disorders, myocardial ischemia, arrhythmia, and even death[1]. The ' gold standard ' for the diagnosis of sleep disorders is polysomnography. It is a method of examining the nocturnal sleep of the human body by continuously and synchronously recording nearly 20 indicators such as EEG, EMG, eye movement, ECG, respiration, blood oxygen, limb movement and body position through special instruments during all-night sleep[2]. It is of great significance for the diagnosis of clinical sleep disorders. However, due to the high price of polysomnography, the bound monitoring method requires professional doctors to analyze the diagnosis results, and cannot be used and popularized daily. Therefore, the development of unconstrained sleep monitoring air cushion and sleep quality monitoring research has important engineering application value.

In 1995, the Committee of the American Sleep Disorders Association developed a standard for evaluating sleep quality using physiological information such as heart rate, respiratory rate, and body movement through a large number of experiments. With the development of intelligent wearable devices and dynamic monitoring technology of human physiological information, unconstrained daily sleep quality health monitoring has received extensive attention. Piezoelectric [3], optical fiber [4] and capacitive sensors [5] are used to collect heartbeat and respiratory signals without restraint [6].Such products mainly include smart bracelets, wearable vests, belts, hats and smart mattresses. Among them, the smart mattress is particularly suitable for monitoring physiological information during sleep because of its complete non-wearing feeling. The micro-motion sensitive mattress sleep monitoring system integrates the key technologies of the above system to achieve long-term, unrestrained sleep monitoring [7]; the research status of intelligent mattress and sleep quality assessment.

In this paper, a portable air cushion for sleep monitoring is developed. The hardware is developed by using XGZP6847 pressure sensor, sliding rheostat, AD7705 dual 16-bit ADC data acquisition module and ARDUINO microcontroller development board. A host computer

monitoring software is designed by using LabView. The sleep monitoring method studied in this paper can realize the collection, processing and storage of respiratory signals. The accuracy of the unconstrained sleep monitoring air cushion was verified by comparison with the polysomnography.

2. Development of LabView PC monitoring software

2.1. Test Principle

In this study, the structure of air cushion connecting tube and air pressure sensor installed at the end of the tube was designed. The test principle is that during the breathing process, the gas exchange between the human body and the external environment will produce chest and abdomen fluctuations[8]. Therefore, the air cushion can transfer the gas through the catheter to the pressure sensor, and then obtain the respiration rate (RR), body movement and turning signal. The self-designed air cushion structure is shown in Figure 1.

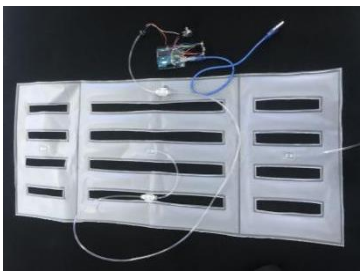

Figure 1 Air cushion structure

2.2. Development of equipment hardware

The development of hardware system consists of four parts, including XGZP6847 pneumatic sensor sliding rheostat, AD7705 dual 16-bit ADC data acquisition module and ARDUINO microcontroller development board. The self-developed air cushion catheter is installed on the XGZP6847 air pressure sensor to input the air pressure signal. The signal is converted into a voltage signal through signal processing on the sensor, and then transmitted to LabViewfor data display and processing through the sliding rheostat, ADC data acquisition module and Arduino microcontroller board.

Using Arduino software programming, set the library function, XGZP6847 gas pressure transmitter module reading range, define variables, set the baud rate, set the AD7705 dual 16-bit ADC data acquisition module AD conversion channel, clock frequency, gain range and sampling frequency, and output the collected data through the digital output port. Finally, the compiled program is downloaded to the single-chip microcomputer for debugging and reading the physiological signal.

At the same time, the data collected by PSG and smart sleep monitoring mattresses is used as shown in Figure 2.

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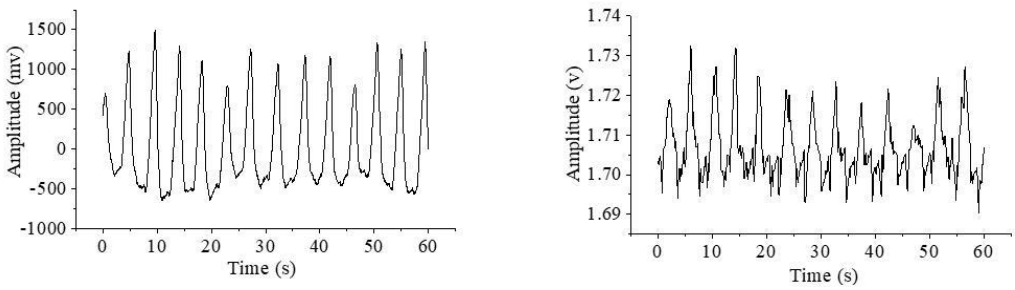

(a)Breathing signal collected by PSG (b)Breathing signal collected by smart mattresses

Figure 2 Breathing signal collected by PSG and Smart Mattress

3. Development of LabView PC monitoring software

LabView is a comprehensive graphic development environment created by the National Instrument Company (NI), Through the serial communication between the VISA module in LabView , the data that can be collected by the air pressure sensor can be collected in real time for real time. Monitor, handle and store.

The front board of the LABVIEW monitoring software designed by the Institute is shown in Figure 3. It is divided into communication modules, signal monitoring modules, wave noise reduction modules, data storage modules.

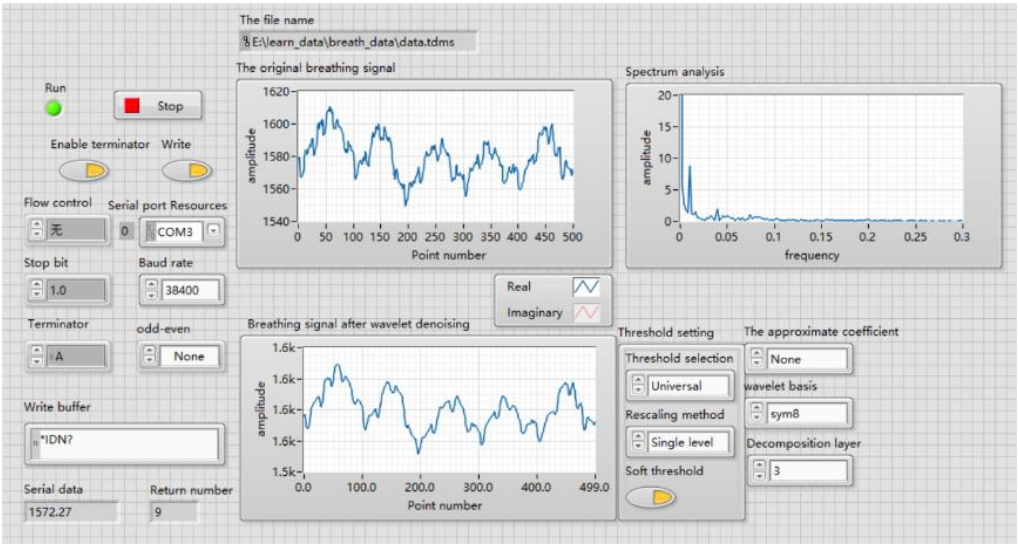

Figure 3 LabView monitoring software front panel

4. Summarized and Prospected

In this paper, a non-binding portable air cushion is used as a new means of monitoring sleep status, which realizes real-time and non-invasive sleep monitoring. The LabView host computer sleep monitoring software is designed to collect, process and store the respiratory signal. Compared with the monitoring results of the polysomnography, the accuracy is high. This device can provide a basis for doctors to guide sleep rehabilitation or disease information mining.

References

[1] Verrier Richard L [Us]; Hobson J Allan [Us]; Lovett Eric G [Us]; Pace-Schott Edward F [Us. Home-Based System and method for monitoring sleep state and assessing cardiorespiratory risk[J]. 1998.

[2] Jiang Fangfang, Wang Xu, Yang Dan. Time-frequency detection method of respiratory components in cardiac shock wave signal [J].Journal of Biomedical Engineering, 2012,29 (03) : 397-401.

[3] Takashi, Koyama, Shinichi. Apnea during Cheyne-Stokes-like breathing detected by a piezoelectric sensor for screening of sleep disordered breathing[J]. Sleep & Biological Rhythms, 2015.

[4] Hsu M H , Fang S C , Wang F T , et al. Sleep apnea assessment using declination duration-based global metrics from unobtrusive fiber optic sensors[J]. Physiological Measurement, 2019, 40(7):075005.

[5] Mukai, Toshiharu & Matsuo, Kazuya & Kato, Yo & Shimizu, Atsuki & Guo, Shijie. (2014). Lying Posture Detection for Unconstrained Measurement of Respiration and Heartbeat on a Bed. Proceedings of the IASTED International Conference on Biomedical Engineering, BioMed 2014. 46-53. 10.2316/P.2014.818-014.

[6] Dai Y , Guo J , Yang L , et al. A New Approach of Intelligent Physical Health Evaluation based on GRNN and BPNN by Using a Wearable Smart Bracelet System[J]. Procedia Computer ence, 2019, 147:519-527.

[7] Zhang Hongjin, Yang Jun, Yu Mengsun, et al.Comparative study of micromovement sensitive mattress sleep monitoring system and polysomnography [J].Chinese Journal of Practical Diagnosis and Treatment, 2004 (6).

[8] Hao and Song.Research on respiratory signal detection methods [J].Micro-nano electronic technology, 2007,44 (7).