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Development of Human Physiological Signal Monitoring Equipment for Sleep Quality Evaluation

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Abstract

Gold standard for diagnosing sleep quality at home and abroad known as polysomnography (PSG) is a method that can assess the health status, but has the disadvantages of poor comfort and high cost. Therefore, studying an unconstrained method to extract information such as breath, heart rate and body movement, physical activity to evaluate sleep quality is a research priority. Additionally, the aging population problem has caused the hidden danger of insufficient medical resources and nursing staff in China. To address this problem, research on the key technology of the intelligent nursing bed, which can extract the physiological signals without restraint was carried out. The propose of studying the air cushion for sleep is to assist physicians in the diagnosis and medication of sleep disorders. Air cushion encompasses the recording, investigation, and interpretation of different physiological signals composed simultaneously. The air cushion type relates to the Respiratory Care system, specifically reveal to a cordial of Sleep-Respiratory monitoring system based on air-bed.

Keywords

Air cushion; polysomnography; body movement; contact and noncontact sleep monitor.

1. Introduction

sleep processes one-third of a lifetime and plays an imperative part in numerous physiological capacities. Recent considers moreover demonstrated a part of sleep in cellular homeostasis and clearance of metabolic squanders. [1].

Polysomnography that diagnoses the "gold standard" of sleep disorders can determine the sleep disorders and sleep apnea hyperpnoea syndrome by using more than ten indicators such as body motion map, respiratory map, and sleep staging chart[2]. As a result of the recent development of smart wearable devices and human body physiological information, dynamic monitoring technology, unconstrained human physiological signal monitoring and sleep quality health management based on breathing and body movements have received extensive attention. At present, the unconstrained extraction methods of human physiological signals are[3]:

(1) A method of monitoring the surface motion of the body caused by breathing and heartbeat using the reflected pulse-Doppler effect such as radar, acoustic emission, and Wi-Fi. However, this method yield is more difficult to distinguish when overlapping signals of multiple people are in the same space[4].

(2) Human physiological signal monitoring methods using piezoelectric, optical fiber, and capacitive sensor. Currently, such products mainly include smart bracelets and mattresses.

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Among them, the smart mattress is especially suitable for elderly health and home care due to its completely no wearable feeling[5].

(3) Breathing is a process of gas exchange between the inside of the body and the external environment. This process causes changes in the thorax and abdomen. The undulations produced during the process can be obtained by the unconstrained acquisition of the above-mentioned sensors built into the mattress. TIn order to remove the physiological and psychological burden of the wearer, the research team of Yu Meng Sun developed a wearable vest, watch, belt, hat, physiological information monitoring system and a fretting sensitive mattress type sleep monitoring system[6].

In this research,the propose of studying the air cushion for sleep, physician and assist in the diagnosis and medication of sleep disorders. Air cushion assigns to the recording, investigation, and interpretation of different physiologic signals composed simultaneously. The air cushion type relates to the Respiratory Care system, specifically reveal to a cordial of Sleep-Respiratory monitoring system based on air-bed.

2. Structure of the Hardware

The non-constrained sleep monitoring hardware is shown in figure 1[5].Different sensor cushions incorporate capacitive sort as well as air. As for sleeping position changes, the weight of each portion of the body will change, at that point the changes in weight will be precisely recorded by numerous sensors, at long last change over them to electrical flag yield and transmit to cleverly gadgets. The development of the hardware system consists of 4 parts, including XGZP6847 air pressure sensor, sliding rheostat, AD7705 dual 16-bit ADC data acquisition module, and ARDUINO microcontroller development board. Among them, the air pressure signal is transmitted to the XGZP6847 air pressure sensor through a self-made air cushion, and the acquired respiratory signal is transmitted to LabView for data display and processing through the ARDUINO microcontroller board.

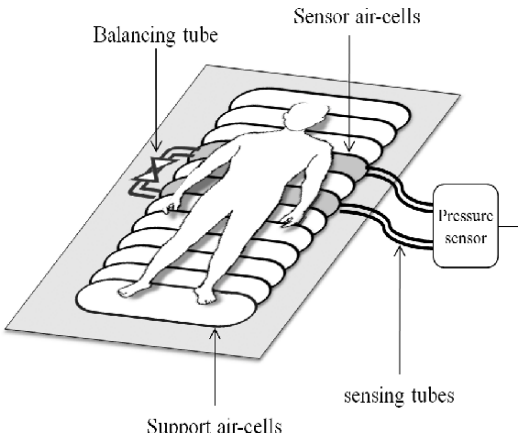

Figure 1: Non-constrained sleep monitoring.

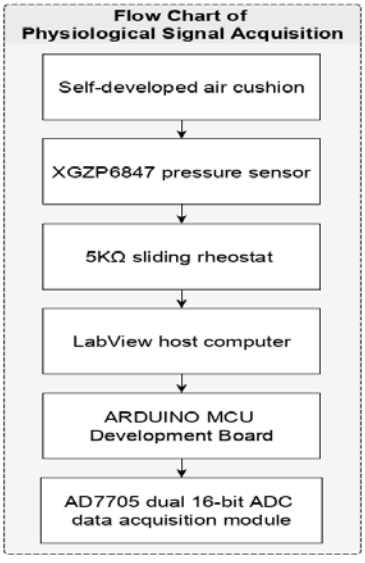

Figure 2: Flow chart of physiological signal acquisition.

3. Development of the Software System

LabVIEW is a graphical programming language designed by National Instruments for scientific and engineering data gathering and reduction. LabVIEW, as the upper computer of the program, adopts graphic programming mode, and can display the collected signals

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through the front panel. The specific steps are to search for serial read and write cases through the Find Case button under the help column in LabVIEW, and then set the port, baud rate and other parameter settings for the case; change some programs to read and write signals and waveform graph.

4. Sleep Quality Monitoring Experiment

4.1. Experiment Design

Sleep associated disorder influences the human body in several aspects. Sleep associated respiratory disorder is in a position to have an effect on the overall sleep best therefore, that excessive sunlight hours sleepiness occurs. In addition, if sufferers are handled at an early stage of the disease, their nighttime and daytime blood strain can be lowered, and the damaging health effects can be reduced. Sleep-related respiratory disorder appears to make contributions as a danger factor for stroke thru hemodynamic and hematologic changes. Sleep apnea may lead to the development of cardiomyopathy and pulmonary hypertension. Early attention and treatment of sleep-related breathing disorders can also improve cardiovascular characteristic. In terms of breathing, both men and women use mixed breathing, while men use abdominal breathing and women use chest breathing. In order to ensure the consistency of the subjects, 10 healthy male (abdominal breathing) healthy subjects without respiratory dysfunction were selected for testing. Their age, height and weight were 23-27 years, 153-180 cm, and 44- Within 97 kg. Experimental precautions (no tea, coffee and alcoholic beverages before the experiment, no mobile phone during the experiment) will be explained to the subjects by the experimental companion Nervousness such as nervousness, fear). During the experiment, they were patrolled every 15 minutes and paid close attention to the breathing depth, breathing rhythm, and snoring[10].

4.2. Experiment Method and Equipment

In order to monitor the unrestrained natural sleep state throughout the night, the subject must lie on a self-developed air cushion before 22:30, and the experimental companion will debug and verify the accuracy of the experimental equipment, while guiding the subject to gradually enter the sleep state. The signal of the polysomnography instrument and the unbound portable air cushion was officially recorded at 23:00, and the experiment was ended at 6:00 the next morning. Monitoring indicators include chest breathing, abdominal breathing, snoring, body movement, and heart rate.The experimental equipment is as follows:

(1)Self-developed unbound portable air cushion

This is often a lean, air-filled pad planned to be situated on top of a sleeping pad. The pressure-sensing cushion records heart rate, breath, and body movement. The self-developed unrestrained portable air cushion is placed under the chest and abdomen of the human body, and the pressure signal generated by the fluctuation of the chest and abdomen motion caused by breathing that monitored to extract physiological signals.

(2)Embla N7000-S7000 Polysomnography

The Embla N7000-S7000 type polysomnography was used for verification experiments. The Embla N7000-S7000 type polysomnography combines advanced integrated digital technology and signal processing technology It is assembled in the same integrated full-lead and multi-lead sleep system. It belongs to type II medical equipment and has high reliability. The method of use is to bind the chest and abdomen breathing belt to the chest and abdomen of the subject to obtain the chest and abdomen Physiological signals.

(3) PC 80B high speed ECG detector signal

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PC-80B Easy ECG Monitor is designed for home use with the purpose of health care, and is suitable for users who may suffer from cardiovascular disease, such as hypertension, diabetes, coronary heart disease, etc., or those who have the symptoms of heart-throb, stuffy chest.

A comparison experiment of air cushion extraction physiological signals is shown in Figure 3.

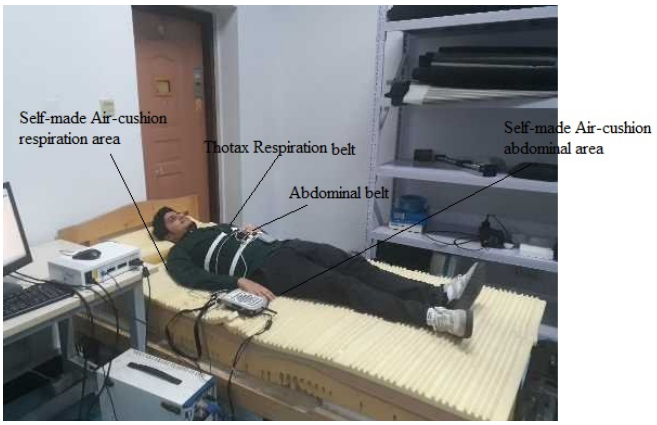

Figure 3: The components of the Air cushion and PSG equipment.

4.3. Experiment Data Analysis

(1) Monitoring of heart rate and respiration

The experimental staff analyzed the chest and abdomen signals of the self-developed hardware in the state of no-body sleep, body movement, and turnover, and compared with the test data of the polysomnography instrument heartbeat signals. Figure 4 is a superimposed signal of heartbeat and breathing obtained by a self-developed device. Figure 5 and Figure 6 is the respiratory and ECG signal obtained by the polysomnography and ECG detector.

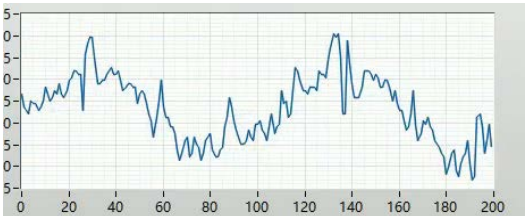

Figure 4: The combination of heartbeat and breathing signals.

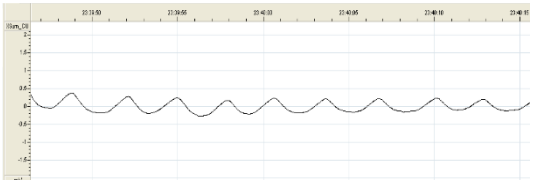

Figure 5: Chest and abdominal signals without body movement.

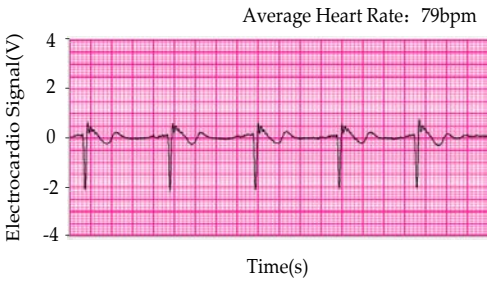

Figure 6: The ECG signal recorded

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5. Conclusion

This paper studies the hardware development and system construction of the intelligent nursing bed based on the method of unconstrained extracting physiological signals. The requirements of the intelligent nursing bed are met, and the motion control of the intelligent nursing bed is realized. The downside of the subject research is that the physiological signals collected simultaneously by multiple sensors are relatively expensive and unsuitable for general use. Finally, the question of how to economically extract two or more physiological signals contained in the human body through a low-power sensor is an area of improvement as part of future research.

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