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A WEARABLE, MOBILE PHONE-BASED RESPIRATION MONITORING SYSTEM FOR SLEEP APNEA SYNDROME DETECTION

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INTRODUCTION

Sleep apnea syndrome (SAS) is characterized by interruptions of breathing. Three types are recognized: obstructive sleep apnea, central sleep apnea and mixed obstructive and central sleep apnea. Overnight polysomnography such as EOG, EEG, EMG, ECG, tracheal noise, nasal and oral airflow, thoracic and abdominal body movements and oxygen saturation are used to diagnose SAS. Therefore, the test restrains the patients to a hospital environment and may produce stresses that may influence the SAS pattern.

In this study, we have developed a new wearable at-home respiration monitoring system. This system records the respiration waveform during and one minute before and after the apnea, and then the mobile phone (PHS) incorporated into the system sends the recorded respiration waveform directly to the hospital server computer. Therefore, using this system does not require an overnight stay in hospital for the test.
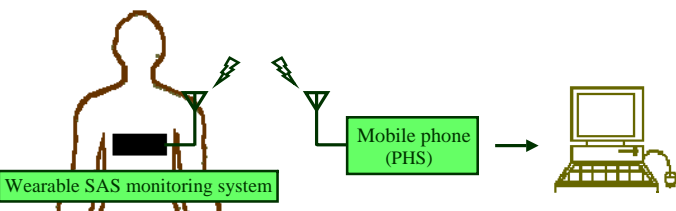
SYSTEM DESCRIPTION

Figure 1 Mobile phone-based respiration monitoring system for sleep apnea syndrome detection and analysis. The system is attached to a shirt and records the respiration waveform. When the patient is apneic for 10 seconds or more, the microcontroller sends the recorded respiration waveform during and one minute before and after the apnea directly to the hospital server computer via the mobile phone. The server computer then creates apnea "filings" automatically for every patient.
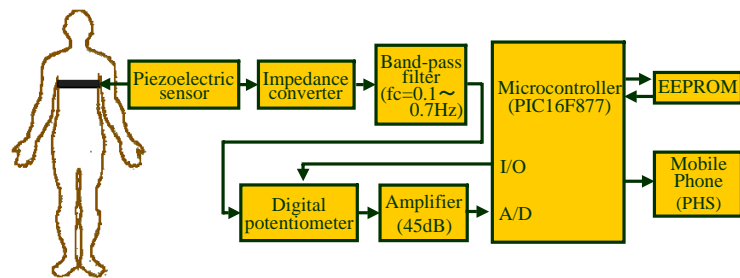

Figure 2 Block diagram of the wearable SAS monitoring system. The piezoelectric sensor detects body movements caused by thoracic excursion. The band-pass filter detects the major respiratory component. The filter output is amplified and fed into the low-power single chip microcontroller. The amplifier output is sampled at 50Hz, and then the data are stored sequentially to the EEPROM for 5 minutes.
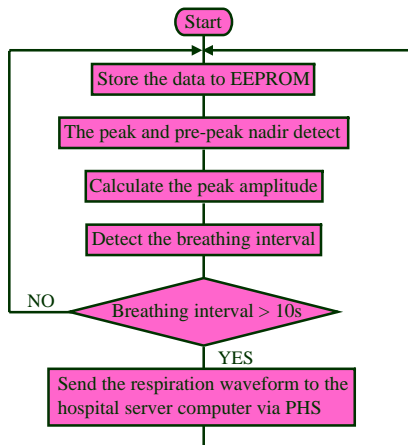

Figure 3 System flow chart. The recorded respiration waveform is saved to the EEPROM. The microcontroller detects the peak and pre-peak nadir from the recorded respiration waveform by a cluster method. The peak amplitude from the pre-peak nadir to the peak is calculated, and the breathing interval is detected by the period between two successive respiration waveform peaks. When the breathing interval exceeds 10 seconds, the microcontroller sends the recorded respiration waveform during and one minute before and after the apnea directly to the hospital server computer.
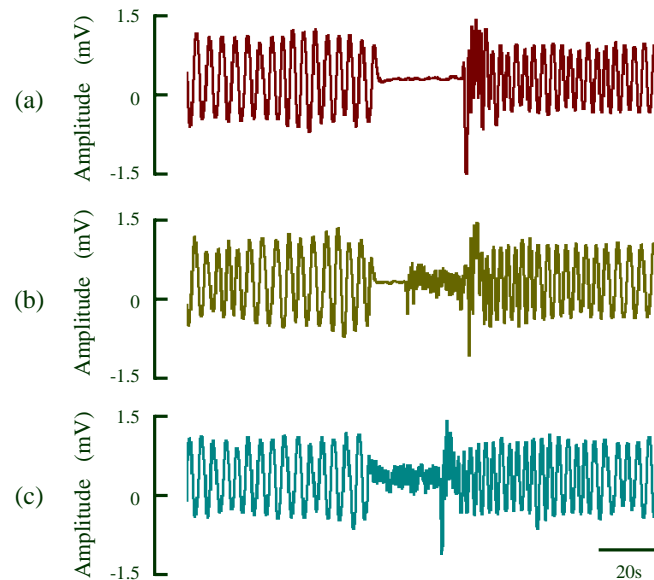
RESULTS

Figure 4 Thoracic body movements recorded from a central sleep apnea patient (*plot a*), a mixed sleep apnea patient (*plot b*) and an obstructive sleep apnea patient (*plot c*). (a) shows the disappearance of a complete respiration waveform for 25 s. (b) shows a mixed sleep apnea type, which has apnea for 9 s and then small thoracic body movements. (c) shows small thoracic body movements for 20 s.

CONCLUSION

The developed system recognized three SAS types and extracted one minute before and after the apnea by monitoring the time-frequency analysis automatically. The system can be used at home and be self-applied by suspected apnea patients for monitoring SAS episodes during sleep under familiar circumstances.

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