Sleep Apnea Monitoring and Tracking System: Novel Application of Integrated Sensor, Persuasive Technology, Soft Computing

Atiya Masood Rana
Yanbu University College

Abstract

Obstructive Sleep Apnea (OSA) is a disease in which airway blocks during sleep, leading to serious consequences. The current standard of diagnosis for OSA, polysomnography (PSG), requires that the patients spend one full day in a hospital. It is an expensive, inconvenient procedure and not accessible by each and every patient. So, home monitoring sleep apnea system is needed that would provide an inexpensive and comfortable solution. This research will propose an embedded system that processes different bio signals, persuasive technology for sleep analysis and soft computing for inference and diagnosis of OSA. The proposed solution is a low cost, low power, reliable, non-intrusive, and non-invasive vital signs monitor that processes and analyses the sleep data. After that this data transmit to the user's smart phone by using Wireless radio and diagnosis OSA by using neural network and fuzzy logic.

Keywords—Sleep apnea, polysomnography, Soft- computing , Fuzzy logic, Neural Network, Embedded System, Persuasive Application

1.Introduction

Sleep Apnea is a common sleep disorder that pauses spontaneous breathing during sleep. This pause or absence of breathing can last from 10 to 20 seconds and may occur up to 30 times or more in an hour. [1] There are three type of sleep apnea, Obstructive, Central and Mixed.

Obstructive Sleep Apnea (OSA) is the most common type of Apnea that occurs when soft tissues of a throat relaxes during sleep and block the airway [1] .This blockage (fully or partially) drops oxygen level in blood. If oxygen level reaches to the dangerous level, brain responds by briefly disturbing our sleep and opens the wind pipe that resume normal breathing with gasp or long snoring sound. OSA release stress hormones that increase the risk of high blood pressure, diabetics and heart diseases [2]. Moreover, sleep apnea may also change our day time behaviour such as hyperactivity or inattention. Therefore, it may cause be the car accidents with an estimate 36% of all fatal car accident resulting from driver drowsiness.[3] Finally poor sleep due to OSA can affect memory [4,5] and cognitive functioning [6] . Although OSA is one of the biggest threat of life but still it is difficult to diagnose. One of the common methods for diagnosing is polysomnogram (PSG)[1] that records brain signals, eye movements , heart rate and blood pressure . PSG often needs specialized sleep lab and patients at least admitted over night for monitoring. It is an expensive, inconvenient procedure and not accessible to each and every patient. So, home monitoring sleep apnea system is needed to provide inexpensive and comfortable solution.

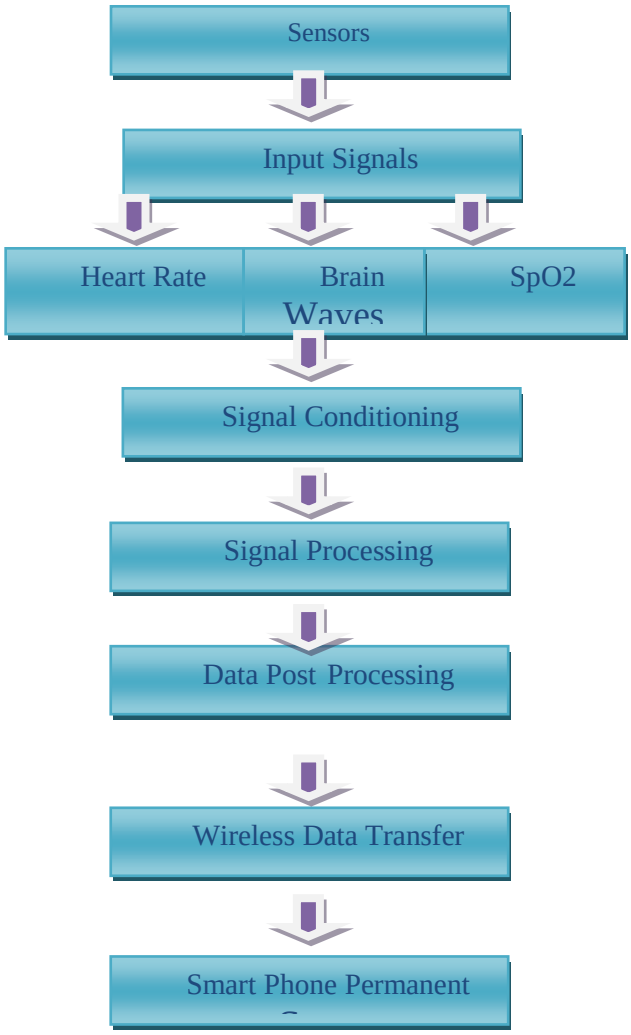
2.Proposed Solution

2.1 Embedded System

OSA is an important public health issue with challenges for diagnosis and treatment [7]. It is estimated to occur in about 7% of the population from which more than 85% remain undiagnosed. [7] .Current methods of diagnosis and treatment are cumbersome, expensive and inconvenient for patients. Therefore, a new monitoring device of OSA is needed that patient may use in home environment rather than in a sleep lab. Several researches of apnea had been done and are still going on for diagnosis, such as determine snoring sound, measure heart and brain waves. Theses researches haven't focused on all symptoms of OSA. Therefore, Future research needs to focus on human behavior, brain waves signal, heart rate, blood oxygen saturation for diagnosing.

Proposed system is a smart phone application. It is an embedded system because that is processing different bio signals (brain, heart and blood oxygen saturation SpO2) and finds correlation between those

signals to increase the reliability. This embedded system consists of photoplethysmograph (PPG) as it gives a continuous and real time measurement. PPG signal can also be employed in other vital information's non-invasive measurement, such as the blood sugar and the breath rate. The sensor will be located in a wristband and measure heart rate and oxygen saturation. Another sensor that will be in a headband will track brain activities or waves (Alpha, beta, delta or theta). This result will be sent over the wireless link to the smart phone for further diagnoses of OSA. Figure 1 is a mock-up of suggested embedded system.



Figur1. Suggested embedded System

2.2 Persuasive Application

The proposed system also has persuasive application that includes self-monitoring and feedback to obtain and maintain healthy sleep habit. It estimates a person's sleep schedule, measures person's day time sleepiness by using **EPWORTH SLEEPINESS SCALE (ESS)** and provides summary of feedback to show the current state of patient sleep. This application will get the user feedback about their past traumatic event because sleep apnea can be triggered by highly stressful emotion.[8]. This feature has never been used in any sleep monitoring technology.

2.3 Soft Computing

One of the most important features of this application is diagnoses. Fuzzy logic and neural network will be used for diagnosis of OSA. Inference engine will use sensor input, sleep analysis, obesity, and traumatic event and apply neural and fuzzy algorithm in order to extract knowledge as output. In future it will help physician to diagnose OSA.

Furthermore, this system records patient's age and gender that is a future research need, According to Healthcare Research and Quality Effective Health Care Program "Age and gender are specific criteria for abnormal breathing (or OSA) and has highest priority of future research[9]. In proposed system patient's record their age and gender. This information will be recorded in sleep disorder centre for future research. Figure 2 will give a complete idea of OSA Package.

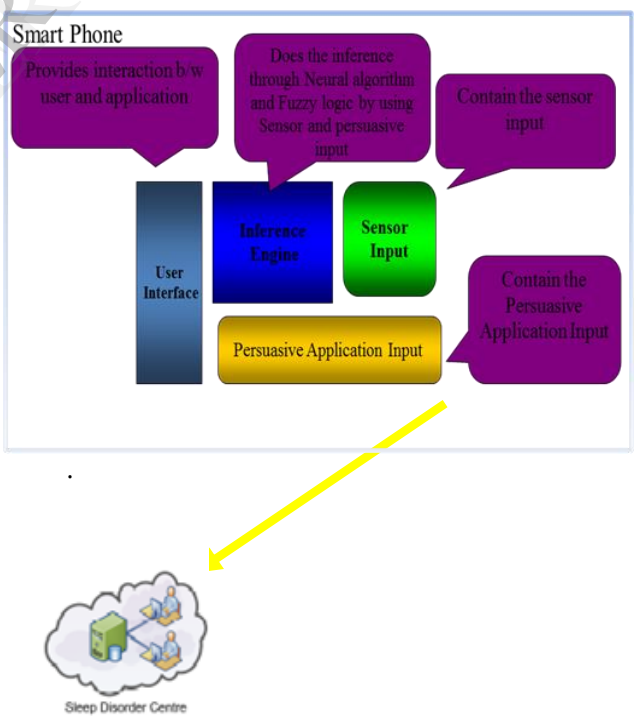


Figure2. Architecture of Monitoring Sleep Apnea

3.Goal

Develop a low cost, low power, reliable, non intrusive, and non-invasive vital signs monitor that processes and analyses the data acquired from sensors, sleep schedule and feedback and transmit data to the user's smart phone by using Wireless radio and diagnosis OSA.

4.Significance

1.According to the Agency for Healthcare Research and Quality Effective Health Care Program future research of sleep apnea needs .[9]
2.Age and gender specific criteria for abnormal breathing (or OSA)
3.Routine (or selected) screening for sleep apnea
4.Design diagnostic algorithms that diagnose in portable monitors (smart phone).
5.Focusing on traumatic event.

5.Conclusion

The proposed solution is for an OSA low cost, low power, reliable, non-intrusive, and non-invasive vital signs monitor that processes and analyses the sleep data. This proposed system helps patient to monitor and diagnosis of OSA at home.

6.References:

[1].*Sleep Apnea*. (n.d.). Retrieved from National Institute of Health: http://www.nhlbi.nih.gov/health/health-topics/topics/sleepapnea/
[2].Ayas, N. W. (2003). A prospective study of sleep duration and coronary heart disease in women. *Archives of Internal Medicine, 163(11)*, , 205–209.
[3].Leger, D. (1994). The cost of sleep-related accidents: a report for the national commission on sleep disorders research SLEEP17(1).
[4].Maquet, P. (2001). The role of sleep in learning and memory. *Science, 294(5544)*, , 1048–1051.
[5].Wagner, U. G. (2004). Sleep inspires insight. *Nature,427(6972)* , 325-355.
[6].Faubel, R. e. (2009). Sleep duration and health related quality of life among older adults: a population based cohort in Spain. *SlEEP* , 1059-1068.
[7].Leier, M. (n.d.). Sleep Apnea Detection on Babies and Children with Shoe Integrated Sensors.
[8].Damaris Drewry, P. P. (2012). *Sleep Apnea: A New Mind/Body Solution*. Retrieved from Woman: http://www.wncwoman.com/2012/06/04/sleep-arena-a-new-mindbody-solution/
[9].Tufts Evidence-based Practice Center, T. M. (2012). *Future Research Needs for Diagnosis of obstructive Sleep Apnea.* AHRQ Publication No. 12-EHC031-EF.