Sleep Apnea Detection Using Smart Watch And Data Analysis Using Neural Networks

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Abstract: A type of medical disorder which causes disturbance in the normal sleeping pattern of the person is sleep disorder. The physical, mental, social health of an individual are subjected to serious problems due to some of the sleeping disorders. If untreated, this may also become fatal. Some common types of sleep disorder are sleep apnea, jet lag, restless leg syndrome, sleep walking, narcolepsy, sleep paralysis, etc.., sleep apnea diagnosis is carried out in a supervised clinical environment which is called polysomnography. This involves continuous and complete monitoring of body functions and specific parameters of the patient by which the presence of the disorder can be indicated. This proposes a sleep apnea device of continuous monitoring that detects the parameters of spo2, heart rate, blood pressure in real time. To display these parameters, a liquid crystal monitor is used. The physiological parameters, that are measured, are transmitted to a smart phone from the monitoring device using Wi-Fi or Bluetooth, and further analysis can be carried out. The experimental results show that this wearable device along with a non-invasive BP measurement using cuff-less method provides a diagnostic result that is reliable. The developed low cost device could avoid complicated procedures and gives continuous monitoring of the sleep apnea disorder.

Key words: sleep apnea disorder, heart rate sensor, spo2 sensor, cuffless blood pressure

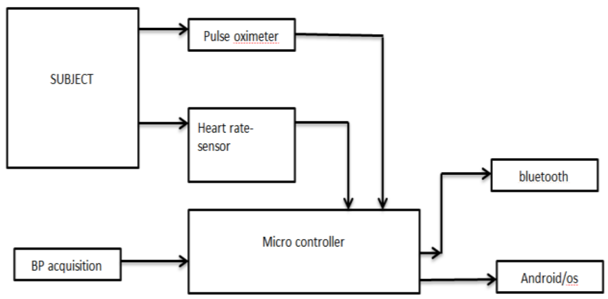
INTRODUCTION

Every individual require a minimum of eight hours sleep at night, the insufficient or disturbed sleep of an individual cannot allow them to function effectively in routine work. This kind of disturbed sleep pattern increases the broad range of sleep disorders. Any medical disorder that is associated with the improper sleep pattern is known as sleep disorder, very common types of the sleep disorders are sleep apnea, insomnia, restless leg syndrome etc., The obstructive sleep apnea disorder is caused due to the repeated blockage of upper airway passage during sleep. The major causes of the sleep apnea depends on an individual's medical condition and the physiological structure. Obesity, premature birth, depression, genetic syndromes, large tonsils are the common causes of the sleep apnea disorder. The unhealthy lifestyle habits like drinking, smoking, unhealthy food diets and eating patterns increase the risk for sleep apnea. The age and gene history also plays major role in risks for sleep apnea. If the sleep apnea is left untreated it may also lead to greater risk of heart failure, stroke, coronary heart disease, high blood pressure, type 2 diabetes, adult asthma etc., The estimation of the sleep apnea disease prevalence is at a range of 3% to 7% where in India alone it is estimated as 3.4 % to 4.96 %, men face this problem more than that of the women's. The traditional method used for the diagnosis of the sleep apnea is the polysomnography where the sleep events of the sleep apnea patients were observed and recorded in a supervised sleep clinic. The activity of the muscles responsible for the breathing movement, heart rate, brain activity, blood oxygen saturation level during the sleep are recorded and estimated for the sleep apnea event. The severity depends and increases with the number of sleep apnea events acquired per hour of sleep study. The portable sleep apnea monitors are devices used currently in the diagnosis. This paper presents the design of a wearable smart watch which diagnose the sleep apnea events with the help of three parameters heart rate, blood oxygen saturation level and the blood pressure where the heart rate and the blood oxygen level are obtained using the sensors and the blood pressure is obtained using cuff-less method.

Tingyu Sheng Et al describe a portable and wearable design of a watch which helps in the diagnosis of the sleep apnea, they equipped several sensors to acquire some required physiological data for their sleep apnea watch. Breathing movement, respiratory flow, ECG are used for the diagnosis here in their watch. The normal and abnormalities are estimated using these parameters through their developed algorithm. Cheng Shi Et al describe about the design and development of the portable device for the diagnosis of sleep apnea which utilize three different sensors for the acquisition of the certain physiological parameters like blood saturation level, heart activity, breathing movement. A sleep apnea epoch classification is performed using the single lead ECG and these sensor signals are sent to the app developed for the smart phone where the further signal processing and diagnosis is done. Yan Li Et al describes about the method of implementing photoplethysmographic signal for the diagnosis of obstructive sleep apnea. The patient who are suspected to have sleep apnea disorder are taken for this photoplethysmograph monitoring and their results are compared with the results acquired through the polysomnographic method. The calculation of the ppg and psg index are correlative which made them to conclude that the overall specificity and sensitivity are good for performing the diagnosis of sleep apnea disorder. Kong Yien Chin Et al describes about the method of blood pressure acquisition through the both non- invasive and cuff-less means in real time. The device is named as check me which is calibrated in such a way that acquires the systolic blood pressure of an individual and the analytical calculations are performed using the algorithm developed for the check me device using the data acquired. The aim of the study was to continuously monitor the OSA patients using developed prototype device. The ultimate objective of this study focuses on the detection of heart rate, oxygen saturation level and cuff-less blood pressure for the sleep apnea disorder and normal subjects.

METHODOLOGY

The block diagram shown below gives a brief description of the working method involved in sleep apnea smart watch, this block diagram comprises of three main units which does the actual working of the system. They are unit of signal accession, signal procession unit and the unit for display system.



The signal accession unit comprises of the two different sensors spo2 sensor and the heart rate sensor, here we used Max30100 and HW01 sensors for acquiring the respective parameters. The microcontroller used here is arduino UNO (ATmega328P) which is programmed for the signal processing and the display system used is LCD.

A. Heart rate sensor:

The photoplethysmograph sensor HW01 is used in sleep apnea smart watch. The LED and light detecting resistor are used in the working of this sensor. The pulses caused due to the heart beats produces blood flow variations in any parts of the body. These pulses are picked up by the sensor in order to calculate the heart rate of an individual. The careful placement of the heart rate sensor avoids the motion artifacts and provides accurate heart rate of an individual. The central wave of the infra-red emitter is 940 nm and the spectral bandwidth is 42 nm. The maximum sensitivity of the detector wavelength is 920 nm an the sampling frequency is 500 HZ.

B. Spo2 sensor:

The pulse oximeter module Max30100 is used to monitor the arterial blood oxygen saturation. Pulse oximetry is based on the diagnosis of arterial oxygen saturation which can be achieved utilizing wavelengths 660nm and 940 nm, where the absorption of these two selected wavelength is used to differentiate the reduced hemoglobin from oxygenated hemoglobin. The operating current and operating voltage of the spo2 sensor is 100 mA and + 5v Dc regulated respectively.

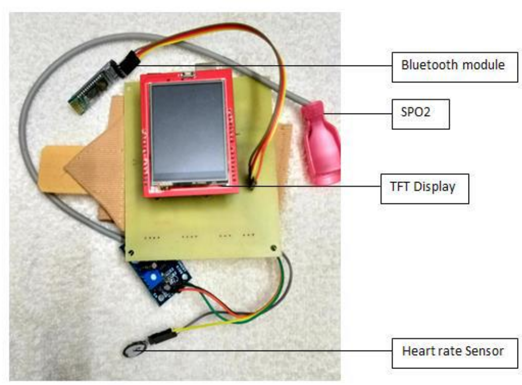
C. Blood pressure accession:

The blood pressure acquisition that is performed by both non-invasive and cuff less means is achieved by accession of blood pressure based on the comparative study. So we obtain the blood pressure of an individual by means of comparative study that is the calculative value which is obtained according to the heart rate and the spo2 appropriately. We have datasets in a library which comprises of both the pulse and spo2 value depending upon which the blood pressure is plotted inside the datasets. So we can perform our blood pressure diagnosis where we compare our obtained spo2 value and pulse value with the reference (template) datasets and later it gives the appropriate blood pressure value with respect to that of the estimated spo2 and pulse rate.

D. Microcontroller:

Arduino Uno is a microcontroller of board based on the ATmega328P and it is used as the interface for the respective sensors and we use arduino software and programing for the required format of output. Classifiers: An algorithm that comprises of the different mathematical function used to do classification especially in concrete implementation is known as classifier. Here we have used three different types of classifiers to classify our normal data from abnormal data they are support vector machine, Navies bays, Multilayer perceptron.

WORKING MODEL



The sleep apnea smart watch is designed to be the wearable for the continuous monitoring and information gathering system for the diagnostic purpose. We utilize the certain physiological parameters like blood pressure, blood oxygen saturation level and heart rate which are acquired using sensors and processed using microcontroller. And we use SVM classifier to classify normal from sleep apnea subjects whereas the existing sleep apnea device uses different relevant parameters for the monitoring purpose and they may require quite considerable area for the respective device. The design and fabrication of our entire proposed system confirms the data and results that we have obtained and listed above. Tingyu Sheng et al explain about the diagnosis of sleep apnea using wearable wrist watch by using different parameters like blood oxygen level, respiratory flow, breathing movement. Here in our device we have used blood saturation level sensor to find the percentage of spo2 which indicates the sleep apnea event.

Kong Yien Chin et al explains about the cuff less means of measuring the blood pressure in real time. The acquired observations are sent through the Bluetooth. The algorithm developed for the device provides the measurements through the analytical calculation. We use the comparative study and algorithm for the measurement of BP in our wearable device.

RESULT AND DISCUSSION

We have conducted the test with the some normal volunteers and acquired the relevant parameters. The parameters observed more or less meet the accuracy of the same parameters obtained through the polysomnography method. The following output shown in figure 5.1 the parameters obtained through the test conducted.

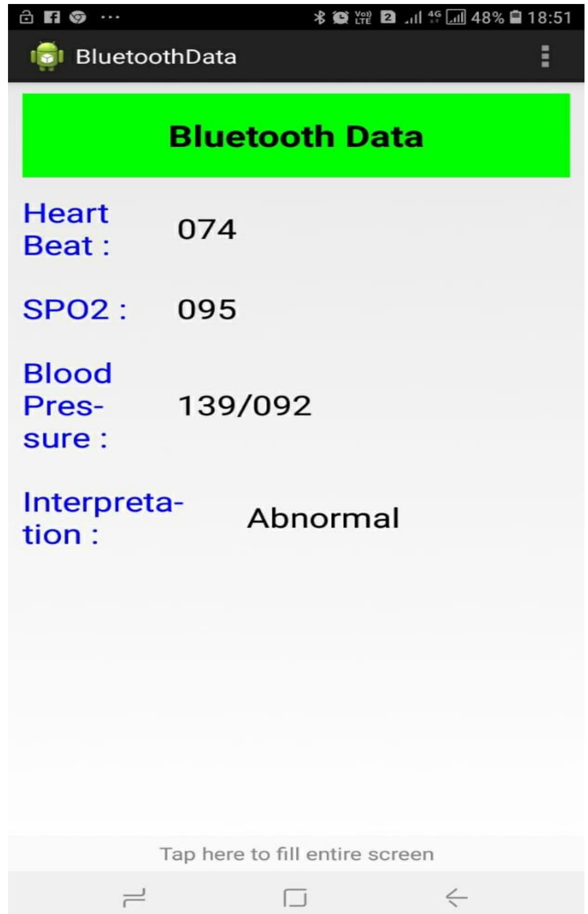
The following tabulation is the results obtained from our sleep apnea watch

Case	Heart rate	SPO2	SYSTO -LE	DIASO -LE	SYSTO -LE	DIASTO -LE
Sleep apnea (N=30)	76.77± 5.43	88.6±3 .43	130.4± 4.06	84.133± 4.13	131.4±4. 34	85.8±3.23
Normal (N=30)	63.233 ±4.58	89.9±2 .97	119.6± 2.83	80.56±4 .43	119.26±2 .54	78.866±4. 36

The output of the normal data that is classified from abnormal data using three different types of classifiers (support vector machine learning algorithm, Navies Bays algorithm and the multilayer perceptron) are as follows

Classi -fier	Accura -cy	Misclassi- fication	TP	FP	TN	PPV	NPV
SVM	0.95	0.05	0.933	0.033	0.96	0.96	0.93
NB	1	0	1	0	1	1	1
MLP	0.983	0.016	1	0.033	0.96	0.97	1

The Final result of application software of the developed device is shown in the figure 5.7



This sleep apnea smart watch is designed to be the wearable for the continuous monitoring and information gathering system. We use oxygen saturation level, heart rate and the blood pressure which is obtained using the cuff less and non-invasive method. And we use SVM classifier to classify normal from sleep apnea subjects and the obtained data from the subjects are given in three different types of classifiers like SVM, navies base and, multilayer perceptron in order to differentiate subjects and through employing these three different types of classifiers we could know the best classifier for the classification of normal from abnormal subjects. The existing sleep apnea device uses different relevant parameters for the monitoring purpose and they may require quite considerable area for the respective device.

CONCLUSION

In this paper we have developed a wearable continuous sleep apnea monitoring system which can measure spo2, heart rate and blood pressure by cuff less means in real time and this overcomes the complexities of the other commonly used portable sleep apnea device. The observational values obtained through our device shows the high consistency with polysomnography methodological results and this brings the capability of sleep apnea monitoring to wrist-based wearable in a cost-effective, power-efficient manner. This expands the screening scope of sleep apnea syndrome which can also be used for the further treatment analysis process.

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