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An Analysis of Sleep Apnea: Detection and Treatment Approaches

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Abstract: *A review of sleep apnea diagnosis and treatment techniques is presented in this publication. The most prevalent kind of breathing-related sleep disturbance is sleep apnea. It may take many different forms, such as involuntary nocturnal activities like night terrors or teeth grinding. Narcolepsy, hypersonic, sleep talking, sleep walking, and bedwetting are the most prevalent sleep disorders. A dangerous sleep disease called sleep apnea causes breathing to stop while you're asleep. During sleep, breathing pauses happen at least thirty times. These pauses range anywhere from a few seconds to several minutes, following which regular breathing resumes. Patients with untreated sleep apnea may stop breathing hundreds of times while they sleep, which may lead to atrial fibrillation, cardiac arousal, stroke, brain tumors, and other vascular disorders that can be fatal by the age of 65. Smokers are more likely to develop sleep apnea. According to a number of studies, smokers who smoke more than two packs a day are 40 times more likely to develop sleep apnea than nonsmokers. The topic of identifying sleep apnea from respiratory episodes and heart rate is covered in this review. There is also discussion of the published research on sleep apnea and its treatment options.*

Keywords: Sleep apnea, detection methods, treatment techniques, polysomnography, machine learning

I. INTRODUCTION

Sleep-related respiratory problems affect around 10% of middle-aged adults [1]. Because of its long-term impact on the cardiovascular system, the respiratory issue is considered a major risk factor based on morbidity and death. Cardiac arrhythmia is intimately linked to heart rate variability and sympathetic modulation. Breathing pauses of ten seconds during sleep are a hallmark of both apnea and hypopnea. Based on respiratory functions, there are three forms of sleep apnea. Obstructive sleep apnea is the first kind, which happens when a patient stops breathing continuously due to an air lock in their upper airways. Central sleep apnea, on the other hand, happens when there is an air lock in their respiratory effort. The third kind is called mixed apnea, which combines central and obstructive sleep apnea. Because to upper airway blockage, this apnea is identified by a lack of respiratory effort without air exchange. Different techniques and procedures are used to diagnose sleep apnea, and various treatments are used to address the condition [2, 3]. The following methods for identifying and treating sleep apnea are reviewed in this study: 1. Constantly elevated positive airway pressure 2. Single-lead ECG automatic detection; 3. Smart cushion system; 4. Sensor-based Micro-Electro Mechanical System

Discussion

A. Positive Airway Pressure Constantly Nasal CPAP was first used to treat sleep apnea condition in 1981 by Sullivan and associates. One treatment method for sleep apnea, particularly OSA, is the use of CPAP devices [4]. The automated CPAP device has been widely utilized to self-adjust the air pressure level according to the user-specified set point. [Table/Fig-1] shows the basic mask installation configuration when sleeping. In order to adjust the air pressure level when respiratory events during sleep change, the automated CPAP device was also created [5]. When a sleep apnea episode is detected, the Automatic Positive Airway Pressure (APAP) device automatically adjusts the pressure level to help patients with low airway pressure. The comparison of CPAP and APAP devices is shown in [Table/Fig-2].

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B. Electrocardiogram (ECG) based Sleep Apnea Detection Detection Module:

Two characteristics are used to identify sleep apnea: 1. RR interval time series standard deviation; 2. RR interval time series correlation coefficients. Module for Respiration: To extract a respiratory event from an ECG using a single lead, three algorithm states are used and contrasted: ECG-derived respiration, kernel principal component analysis (kPCA), and principal component analysis (PCA) are the first three methods. The Radial Basis Function (RBF) kernel of the least-squares support vector machine classifier receives the features as input. Eighty ECG recordings were used in a research by Varon C et al. to identify sleep apnea [6]. An 85%

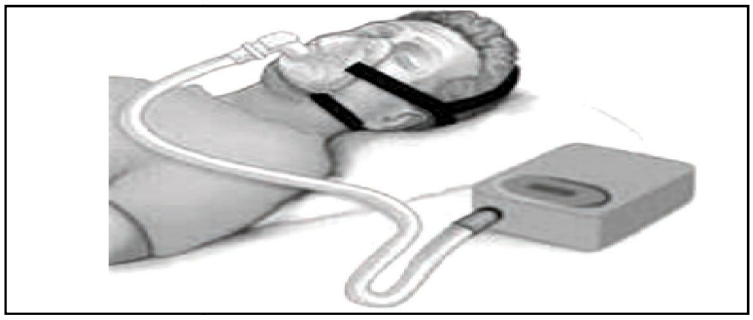

Figure 1 Placement of continuous positive airway pressure mask during sleep.

CPAP		APAP	
Advantages	**Limitations**	**Advantages**	**Limitations**
Noninvasive	Increase of expiratory effort	Fluctuation between low and high level pressure on whole night and automatically adjusts the pressure level	APAP algorithm varies from one person to another
Immediate relief	Sense of forced air through the nostrils of the patient	Automatic elevation of pressure	During apnea events, sometimes the pressure change will be slow
Reduction of heart problems	Uniform maintenance of pressure level set by physician	Uniform maintenance of pressure level set by patient itself	More expensive

Table2 Comparison of continuous positive airway pressure (CPAP) and automatic positive airway pressure (APAP) devices.

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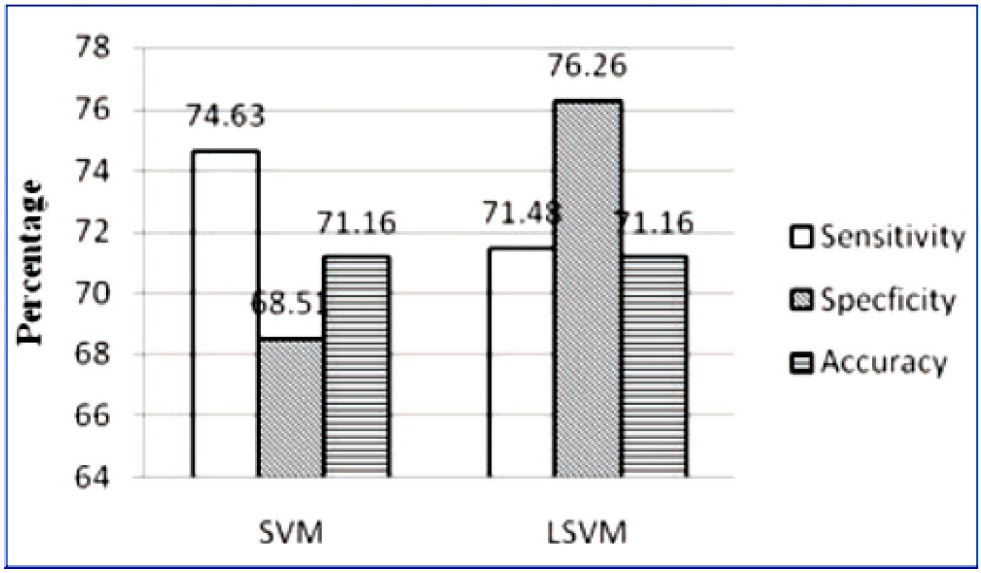

Fig 3: Performance measures for support vector machine (SVM) and least square support vector (LSVM) machine from linear condition [5].

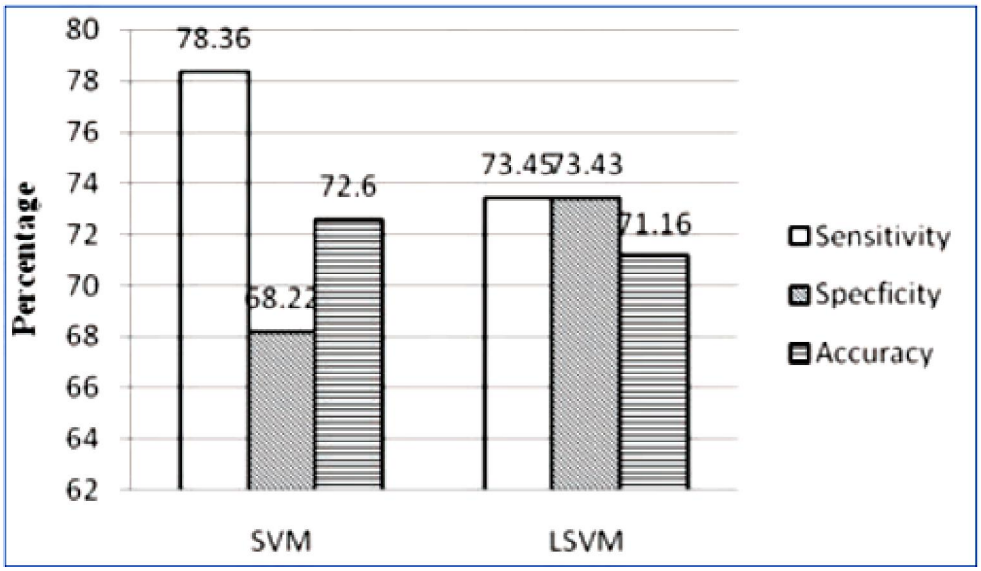

Fig 4 Performance measures for support vector machine (SVM) and least square support vector machine (LSVM) from polynomial condition [5].

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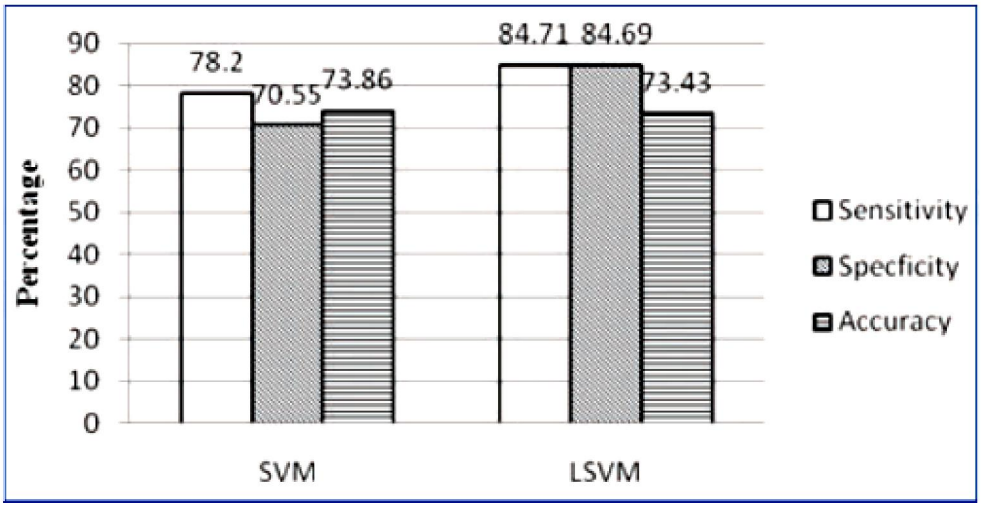

Fig-5]: Performance measures for support vector machine (SVM) and least square support vector machine (LSVM) using radial basis function kernel [5].

A minute-by-minute analysis of hyperpnoea. Additionally, apnea and no apnea recordings were classified with 100% accuracy. Determining the ECG minute contamination threshold for apnea categorization was part of the process. The findings of the research.

Fig-6: Automatic adjustable smart pillow system.

showed that the ECG sensor detected sleep apnea with a high degree of accuracy [6]. Additionally, artifacts were automatically identified based on the amount of contamination in each ECG segment. QRS complex components were used to identify morphological changes brought on by sympathetic activity during apnea. The respiratory event and heart rate details were extracted using orthogonal subspace projections [6].

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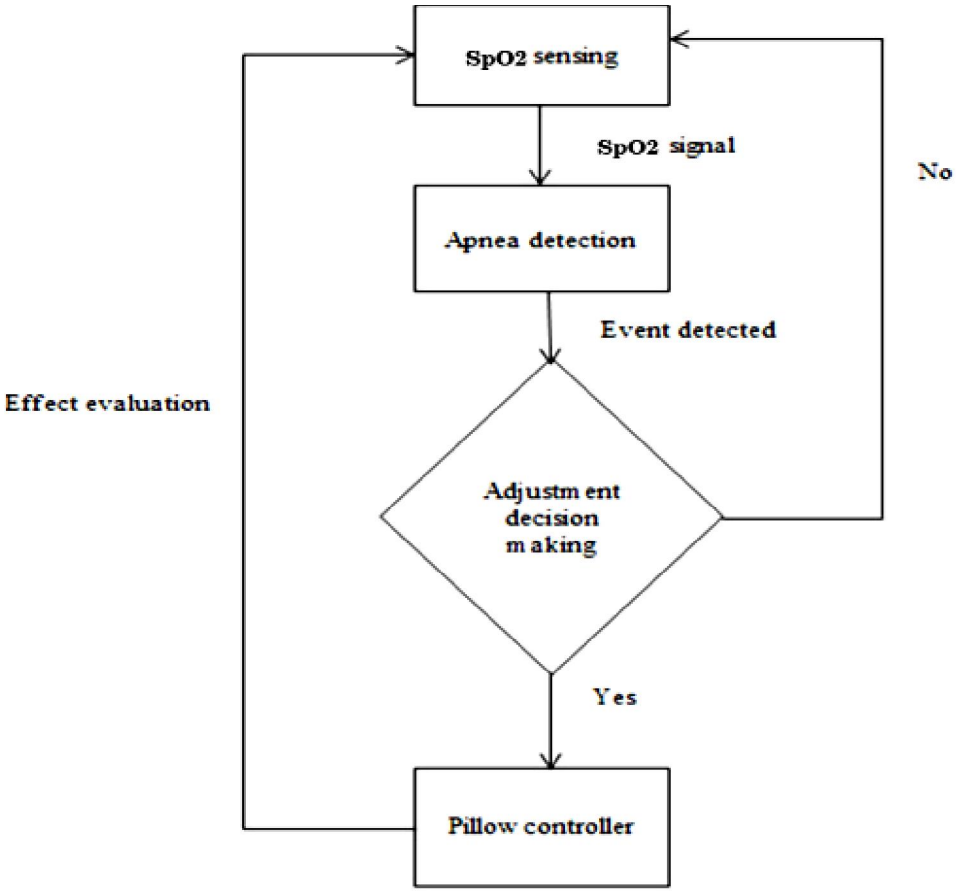

Fig-7: Typical work flow of automatic adjustable smart pillow system.

Heart rate module: One physiological method for calculating changes in heart rate is respiratory sinus arrhythmia. The two physiological signals are X and Y. X stores the RR time series, while Y uses the PCA and kPCA algorithms to retain the respiratory data from the belly and thorax. The signal X is projected onto subspace V, which is determined by fluctuations in Y, and has a linear relationship with Y. Under the conditions of linear, polynomial, and RBF kernels, Varon C. et al. examined the performance of the tested classifiers, namely Support Vector Machine (SVM) and Linear Support Vector Machine (LSVM) [6]. The sensitivity, specificity, and accuracy of the parameter indices were taken into account. The physionet dataset from [6] was taken into consideration in this work and explained using a graphical form [Table/Fig-3-5]. The Apnea-Hypopnea Index (AHI) is calculated using the RBF kernel performance, which is regarded as prime based on this assessment. The physionet dataset's 10 min/hour threshold is used by the AHI to measure apnea episodes.

C. Auto-Adjustable Smart Pillow System Event detection module: Many people use the automatic adjusting smart pillow technology in [Table/Fig-6] to identify and cure sleep apnea. Sleep apnea episodes are detected in real time using a blood oxygen sensor. This invention claims that the height and weight of the pillow automatically adjusts when the sleep apnea incident ends. Following adjustment, the sensor observes the blood oxygen signal; due to the success of the adjustment, an appropriate adjustment plan may be found.

Event diagnosis module: This technology, which is noninvasive, affordable, and portable, is based on the feedback control approach. The choice about the pillow modification is made using a classification algorithm. A feedback pillow adjustment algorithm is utilized to determine how to measure the success of the adjustment as well as when and how to change the cushion [7].

Functions of bladder: The largest of the five bladders within the pillow system shown in [Table/Fig-6] is situated first, followed by the second bladder on the right side under the neck. The third and fourth bladders are positioned on the

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pillow's left and right sides, while the fifth bladder is positioned above the user's head. Using an air pipe, this device uses air electrical pumps to inflate and deflate the bladder. [Table/Fig-7] shows how the automated adjustable pillow system works. 40 individuals with sleep apnea participated in trials by Jin Z et al. [7]. The trials' findings demonstrated that the second and fifth bladders, which were positioned under the head and neck and had pressure ranges of 7000–2000 and 2000–7000, respectively, were used to identify apnea.

D. Micro-electro Mechanical System (MEMS) Sensor Based Device In a sleep study, participants spend the night in a clinical laboratory. The high expense of diagnosis results in people not receiving treatment. To diagnose apnea, a MEMS sensor-based device with an apnea detection algorithm was created. It is often used for at-home sleep apnea testing because of its lower cost. This sensor is used in the design and development of a device that uses respiratory signals to monitor airflow. Integrated circuits (IC) for time-domain signal processing then identify the associated apnea episode. IC chips are made using standard 0.5- Complementary Metal-Oxide Semiconductor (CMOS) technology.

This gadget tests respiratory event detection and sleep apnea screening in a clinical setting. AHI are utilized to determine the severity of sleep apnea [8].

II. CONCLUSION

The specifics of sleep apnea detection and diagnostic methods are explained in the literature review. The approaches that are now accessible explain the detection using classifiers and sensors. Sleep apneic events are detected using MEMS sensors and blood oxygen sensors, and the apneic events are classified from the original events using SVM and neural network classifiers. The proper apneic events are computed from the ECG signals, which record both respiratory and heart rate events. Limitations of this evaluation were time, cost, and the ability to calculate sleep apnea while you're asleep. These drawbacks might be examined in order to add much more effective features to the current sleep apnea detecting gadget.

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