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(57) Abstract :

APNEA is asleep-related breathing issue that is normal in grown-ups and can be depicted as an impermanent conclusion in the upper aviation route during sleep. Intricacy, expenses, and holding up records issues, request a streamlined option for sleep apnea-hypopnea syndrome (SAHS) conclusion. The blood oxygen immersion signal (SpO2) conveys relevant data of SAHS also can be efficiently collected of overnight oximetry. In this invention, SpO2 single-channel chronicles from some subjects were gotten at patients homes. They signified used to naturally acquire spectral, statistical, clinical, and non-linear SAHS-related information. Important and non-repetitive data from these examinations was accordingly used to prepare and approve four AI techniques with the capacity to arrange SpO2 signals into one out of the four SAHS-seriousness degrees (no SAHS, mellow, moderate, and extreme). All the models prepared (straight discriminant investigation, 1-versus all calculated relapse, Bayesian multilayer perceptron, and AdaBoost), outflanked the indicative capacity of the ordinarily utilized 3% oxygen desaturation file. An AdaBoost model works with direct discriminants as base classifiers arrived at the most noteworthy figures. It accomplished 0.479 Cohens in the SAHS seriousness order, just as 78.7%, 87.4%, and 92.9% exactness™s in double arrangement undertakings utilizing expanding seriousness limits (apnea-hypopnea list: 30, 15, and 5 occasions/hour, individually). These outcomes recommend that machine learning can be used alongside SpO2 data gained at patients homes to support in SAHS finding improvement.

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FORM 1 THE PATENTS ACT, 1970 (39 of 1970) & THE PATENTS RULES, 2003 APPLICATION FOR GRANT OF PATENT [See sections 7,54 & 135 and rule 20(1)]	(FOR OFFICE USE ONLY) Application No.: .... Filing Date: .... Amount of Fee Paid: .... CBR No.: .... Signature: ....

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6. PARTICULARS FOR FILING PATENT COOPERATION TREATY (PCT) NATIONAL PHASE APPLICATION:

International Application Number	International Filing Date as Allotted by the Receiving Office
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Original (first) Application Number	Date of Filing of Original (first) Application

8. PARTICULARS FOR FILING PATENT OF ADDITION:

Main Application / Patent Number:	Date of Filing of Main Application

9. DECLARATIONS:

(i) Declaration by the inventor(s)

I/We ,Dr.K.Loheswaran,Dr.D.Vijayakumar,Dr. Vootla Subba Ramaiah,Dr.G.Selvavinayagam,Dr. Venkateshwaran Loganathan,Dr. R. Varalakshmi,Dr.L.Srinivasan,Dr. K. Saravanan,Mr.P.Rajasekaran,Dr Lalit Garg, is/are the true & first inventor(s) for this invention and declare that the applicant(s) herein is/are my/our assignee or legal representative.

(a) Date: -----

(b) Signature(s) of the inventor(s): ....

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(ii) Declaration by the applicant(s) in the convention country

I/We, the applicant(s) in the convention country declare that the applicant(s) herein is/are my/our assignee or legal representative.

(a) Date: -----

(b) Signature(s) : ....

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(iii) Declaration by the applicant(s)

- **The Complete specification relationg to the invention is filed with this application.**
- **I am/We are, in the possession of the above mentioned invention.**
- **There is no lawful ground of objection to the grant of the Patent to me/us.**

10. FOLLOWING ARE THE ATTACHMENTS WITH THE APPLICATION:

Sr.	Document Description	FileName

I/We hereby declare that to the best of my/our knowledge, information and belief the fact and matters stated hering are correct and I/We request that a patent may be granted to me/us for the said invention.

Dated this(Final Payment Date): ----------

To The Controller of Patents

The Patent office at CHENNAI

FORM 2

THE PATENTS ACT, 1970

(39 of 1970)

AND

THE PATENTS RULES, 2003

COMPLETE SPECIFICATION

(See Section 10; rule 13)

TITLE OF THE INVENTION

SLEEP APNEA DETECTION METHOD FOR IN BED PATIENTS FROM SPO2 SIGNAL USING MACHINE LEARNING

The following specification particularly describes

the invention and the manner in which

it is to be performed

SLEEP APNEA DETECTION METHOD FOR IN BED PATIENTS FROM SPO2 SIGNAL USING MACHINE LEARNING

FIELD OF THE INVENTION

Field of invention related to Computer Science and Engineering

This invention depicts a framework that can be utilized for exact discovery and forecast of sleep APNEA occasions by utilizing signal pre-processing, feature extraction and grouping methods. Sleep APNEA disorder is described by the rehashed brief end of breathing to the lungs during sleep – a significant medical issue that can prompt diminished daytime work execution and accidents. A few investigations have connected sleep APNEA to atrial fibrillation, stroke, myocardial localized necrosis and abrupt heart demise. A significant and handy issue is hence the preparing of biomedical signs to extricate data that reflect qualities of sleep APNEA.

BACKGROUND AND PRIOR ART OF THE INVENTION

APNEA is a sleep-related breathing issue that is normal in grown-ups. APNEA that goes undiscovered can be a chance factor for some cardiovascular ailments. Consequently, early identification of APNEA in patients is fundamental. At present, arrangement of apnoeic scenes is performed utilizing polysomnography, which is a costly procedure including the patient going through the night in a rest lab associated with gadgets recording a few physiological signals and being observed by clinical experts.

Individuals spend around 33% of their carries on with sleeping. Sleep sicknesses, for example, a sleeping disorder and obstructive rest APNEA, can genuinely influence a patient's personal satisfaction. Rest issues may cause daytime sleepiness, irritability, depression, anxiety, or even death. Rest APNEA condition is a genuine respiratory issue characterized as the interference of typical breath during rest. The most widely recognized sort of rest APNEA is obstructive sleep APNEA (OSA) portrayed by a transient yet monotonous decrease or end of wind stream brought about by the fractional or all-out breakdown of the upper aviation route during rest. OSA happens when mechanical or basic irregularities in the upper aviation route cause interferences in breathing during rest. At the point when the throat muscles falls, the muscles of the stomach battle more diligently against the blocked section. Carbon dioxide at that point develops the circulation system. The individual battles to wake up and the tongue and throat muscles fix, permitting oxygen to stream into the lungs. As an outcome, the nature of rest is undermined by rest APNEA occasions. This causes the person to experience the ill effects of the most widely recognized APNEA related manifestations, for example, extraordinary weakness, hypertension, cardiovascular failures, and strokes.

Sleep APNEA-Hypopnea Syndrome (SAHS) has become a significant focal point of examination in the course of the most recent decades. The purposes behind such interest incorporate its serious consequences for health and personal satisfaction of influenced individuals, just as its high prevalence. Recent investigations evaluated that moderate to extreme SAHS is available in 6% ladies and 13% men in the United States. Patients experience the ill effects of intermittent scenes of complete nonattendance of breathing (APNEAs) and significant airflow reduction (hypopneas) while sleeping, causing oxygen desaturations, feelings of excitement and, in the long run, rest discontinuity. These unwanted impacts lead to daytime side effects, for example, hypersomnolence, subjective debilitation, and depression, which increment the hazard for occupational accidents, non-attendance, and engine vehicle crashes. Moreover, a critical number of neurotic conditions have been identified with SAHS, including hypertension, cardiovascular disappointment, and stroke. As of late, an expansion in disease rate has been likewise recommended.

Disregarding its high prevalence, SAHS is viewed as an underdiagnosed condition. Henceforth, its indicative convention assumes a key job to keep away from time delays in arriving at determination and getting to treatment. Nocturnal in-lab polysomnography (PSG) is the highest quality level to build up SAHS and its seriousness. It incorporates observing and recording different biomedical signals from patients (electroencephalogram, electrocardiogram, wind stream, blood oxygen immersion, and so forth), which expands its complexity. PSG likewise requires a short-term remain of patients in a specific rest unit, outside their standard thing rest condition, where clinicians go to them and guarantee the appropriate working of the test. Subsequently, the requirement for these devoted offices and HR prompts expanded costs. Once PSG is done, SAHS is disconnected analyzed by registering the APNEA-hypopnea record (APNEAs and hypopneas every hour of rest, AHI). In this way, all the biomedical signs recorded during the night need investigating, which infers a huge time utilization.

Complexity, cost, and devoured time lead to a restricted PSG accessibility, which can't adapt to the high prevalence of SAHS. These outcomes in confined access to finding and treatment and, therefore, expanded holding up records. In this respect, nocturnal pulse oximetry (NPO) has gotten a valuable apparatus to conquer a few PSG confinements. Single-channel blood oxygen immersion (SpO2) from NPO measures the rate of oxygen in the haemoglobin of blood, whose solid worth ranges somewhere in the range of 96% and 100%. In any case, apnoeic occasions cause repetitive drops from these qualities (oxygen desaturations). In addition, SpO2 can be easily acquired by utilizing a solitary sensor to put in a finger. Subsequently, NPO is a basic, versatile, and non-intrusive test, which is generally utilized in clinical practice.

Various examinations have assessed the SpO2 signal gained during in-lab PSG as demonstrative other options. The 3% oxygen desaturation index (ODI3), regularly utilized in clinical practice, just as other univariate and multivariate programmed investigations, have been now tried, with the last showing better. Regardless of the promising outcomes that appeared, none of these examinations was centred around deciding SAHS nearness and its seriousness, nor was led including SpO2 chronicles acquired at home. The disentanglement of the demonstrative test has a conclusive objective to move it to patients' normal rest condition, that is, their homes while giving as exact indicative data as could be expected under the circumstances. In such a manner, a few investigations evaluated univariate examinations applied to at-home SpO2 accounts. By the by, they were centred around ODI3 estimation and assessment, and none of them led multivariate examinations. Thus, there is as yet a requirement for additional assessment of AI approaches applied to SpO2 signals procured under naturally practical conditions and concentrated on setting up both the nearness and seriousness of SAHS.

Summary of the invention:

In this examination, we hypothesize that the SAHS indicative procedure might be rearranged by the utilization of an AI approach and the data contained in the at-home SpO2 signal. Likewise, our principal objective is the evaluation of AI approaches with a capacity to consequently build up SAHS and its seriousness, with single-channel at-home SpO2 as the main wellspring of preparing data. In this way, first, we propose an extensive portrayal of SpO2 by methods for programmed extraction of a phantom, non-direct, and measurable includes as of now assessed in the past in-lab examination, just as ODI3. As featured in going before works, these highlights are expected to give helpful and correlative data about SAHS. Be that as it may, such a thorough methodology has not been as of now tried utilizing at home chronicles and may prompt get highlights that offer comparative data, that is, repetitive highlights. An epic feature selection step is incorporated to maintain a strategic distance from this issue. We propose a blend of the Fast correlation-based filter (FCBF) and 'bootstrapping' to locate an ideal arrangement of highlights predictable through an assortment of tests. The exhibition of the FCBF is free of resulting examinations or techniques, which gives us the extra bit of leeway of directing a reasonable assessment of the ideal arrangement of highlights notwithstanding the diverse AI calculations embraced. In this manner, we at long last propose a thorough evaluation of the home SpO2 value via preparing and approving up to four new AI inferred models, extending from easy to complex ones: linear discriminant analysis (LDA), Logistic regression (LR), multi-layer perceptron Bayesian neural network (BY-MLP), and the gathering learning technique versatile boosting (AdaBoost), orchestrated alongside LDA as base classifiers (AB-LDA). Starter investigations of our own bunch have been as of now directed in regards to BY-MLP and AdaBoost, giving indications of the convenience of the machine learning approach for at-home SpO2 chronicles. In any case, the far-reaching approach directed in the current examination has prompted the utilization of various SpO2 data to train the models, just as LDA rather than grouping and relapse trees as base classifiers for AdaBoost. Likewise, these works demonstrated confinements, for example, the absence of appropriate approval and the utilization of a BY-MLP model just prepared for paired characterization. On the other hand, we follow a multinomial way to deal with finding new models with capacity to not just anticipate the nearness of SAHS yet in addition relegate each subject under investigation into one of its four seriousness degrees (no SAHS, mellow, moderate, and serious).

OBJECTIVE OF THE INVENTION:

The objective of the invention is to detect the Sleep APNEA in bed patients from related propensities in statistical, spectral, non-linear, and clinical highlights extracted from SpO2 recordings acquired at patients' home.

STATEMENT OF THE INVENTION:

The blood oxygen immersion signal (SpO2) conveys helpful data about SAHS and can be effectively obtained from overnight oximetry. In this development, SpO2 single-channel accounts from some subjects were gotten at patient's homes. They were used to naturally get factual, phantom, non-straight, and clinical SAHS-related data. Relevant and non-excess information from these investigations was in this way used to prepare and approve four AI strategies with capacity to order SpO2 signals into one out of the four SAHS-seriousness degrees (noSAHS, gentle, moderate, and extreme). In this invention, four new AI models prepared to naturally establish both SAHS nearness and its seriousness by the main utilization of non-excess SpO2 data acquired at the patient's home.

BRIEF DESCRIPTION OF THE SYSTEM OF DRAWINGS

Fig 1: Sleep APNEA

Fig 2: Normal sleep and Obstructive sleep APNEA

Fig 3: System Framework

DETAILED DESCRIPTION OF THE SYSTEM

A three-phase system was used, and it is shown in figure 3. To start with, spectral, statistical, and non-direct highlights were obtained from the SpO2 recordings. These were utilized in light of its revealed value in the in-lab SpO2 assessment. Furthermore, 3% of ODI was too registered because of its significance in clinical practice. Henceforth, 16 boundaries created the underlying list of capabilities. At that point, a programmed determination stage was utilized to dispose of repetitive highlights and get an ideal arrangement among them. The FCBF determination calculation, alongside a bootstrap strategy, was being used for this reason. At last, the perfect method of highlights took care of four machine-learning ways to deal with acquiring LDA, LR, BY-MLP, and ABLDA models. Their exhibitions were, in this way, assessed utilizing a formerly concealed test set.

A) Feature extraction

1)Essential statistics: First-to-fourth request factual minutes were removed from SpO2 in time-space: mean (Mt1), standard deviation (Mt2), skewness (Mt3), and kurtosis (Mt4). These highlights portray focal propensity, scattering, asymmetry, and peakedness of a given time arrangement.

1. Non-linear measures: Central inclination measure (CTM), Lempel-Ziv intricacy (LZC), and test entropy were likewise separated from the SpO2 time arrangement. These approaches have recently demonstrated its utility to portray the stochastic segments present in biomedical signs.
2. Spectral examination: The repeat of the apneic events prompts to break down SpO2 in the recurrence space as well. The otherworldly force density (PSD) of the SpO2 signals were evaluated by the Welch's non-parametric periodogram.

3. Oxygen desaturation record (ODI3): ODI3 reduces the number of drops of the SpO2 benchmark more noteworthy than or equivalent to 3%, partitioned by the number of long periods of recording.

B) Feature reading: the fast correlation-based filter

An automatic feature collection stage was completed to keep a strategic distance from repeated data when making the machine learning models. Our methodology focused on the FCBF calculation, which depends on constant vulnerability as uniformity of the data gain between factors. FCBF is a channel technique and, subsequently, it is free of the AI calculations later applied.

C). Multinomial distribution

After the feature selection, each subject under research was described by an example, xk, which is a vector whose segments are the relating estimations of the ideal chose highlights. These examples were utilized in a multinomial grouping way to deal with foresee SAHS seriousness, that is, to appoint the subjects to one out of the four SAHS seriousness degrees: no-SAHS, mellow, moderate, and extreme. Four AI models were acquired (LR, LDA, AB-LDA, and BY-MLP), which were prepared and assessed with the ideas from the development and test functions, individually.

CLAIMS:

- Detecting APNEA by observing a respiratory exertion waveform for a boundary reasonable for the patient's degree of respiratory exertion.
- Assessing four new AI models prepared to naturally establish both SAHS nearness and its seriousness by the primary utilization of non-repetitive SpO2 data got at the patient's home.
- Every one of them exceeded the regularly utilized clinical list ODI3 while surveying the absolute number of subjects appropriately characterized into one out of the four SAHS-seriousness degrees.
- All the removed highlights yet MF arrived at factually critical contrasts among SAHS seriousness. These highlights were at first picked because of the usefulness revealed in past in-lab contemplates
- A few screening methodologies could be derived from this invention to show its clinical convenience.
- The new machine-learning AB-LDA model, thoroughly approved, arrived at the most remarkable demonstrative capacity contrasting, and crafted by the cutting edge. It very well may be applied to both multiclass and double orders utilizing diverse AHI edges, which features its potential as a SAHS screening instrument.
- AI approach can be used alongside SpO2 data procured at patients' homes to help in SAHS determination disentanglement.

ABSTRACT

APNEA is asleep-related breathing issue that is normal in grown-ups and can be depicted as an impermanent conclusion in the upper aviation route during sleep. Intricacy, expenses, and holding up records issues, request a streamlined option for sleep apnea-hypopnea syndrome (SAHS) conclusion. The blood oxygen immersion signal (SpO2) conveys relevant data of SAHS also can be efficiently collected of overnight oximetry. In this invention, SpO2 single-channel chronicles from some subjects were gotten at patients' homes. They signified used to naturally acquire spectral, statistical, clinical, and non-linear SAHS-related information. Important and non-repetitive data from these examinations was accordingly used to prepare and approve four AI techniques with the capacity to arrange SpO2 signals into one out of the four SAHS-seriousness degrees (no SAHS, mellow, moderate, and extreme). All the models prepared (straight discriminant investigation, 1-versus all calculated relapse, Bayesian multilayer perceptron, and AdaBoost), outflanked the indicative capacity of the ordinarily utilized 3% oxygen desaturation file. An AdaBoost model works with direct discriminants as base classifiers arrived at the most noteworthy figures. It accomplished 0.479 Cohen's in the SAHS seriousness order, just as 78.7%, 87.4%, and 92.9% exactness's in double arrangement undertakings utilizing expanding seriousness limits (apnea-hypopnea list: 30, 15, and 5 occasions/hour, individually). These outcomes recommend that machine learning can be used alongside SpO2 data gained at patients' homes to support in SAHS finding improvement.

SLEEP APNOEA DETECTION METHOD FOR IN BED PATIENTS FROM SPO2 SIGNAL USING MACHINE LEARNING

FIG 1: SLEEP APNOEA

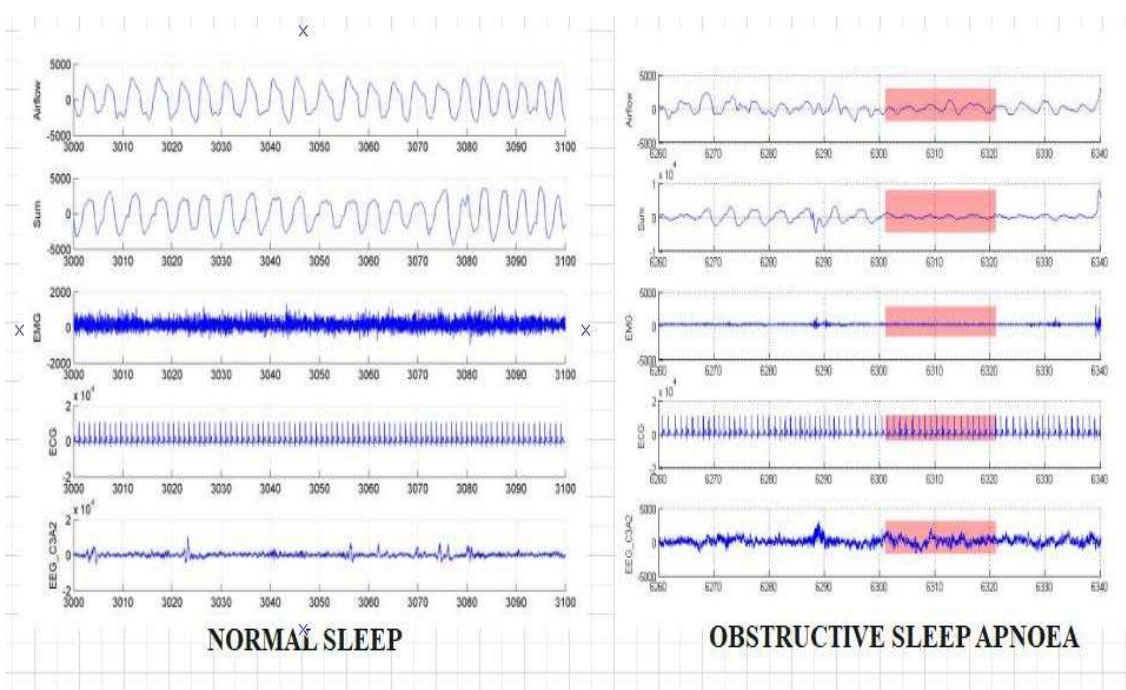

FIG 2: NORMAL SLEEP AND OBSTRUCTIVE SLEEP APNOEA

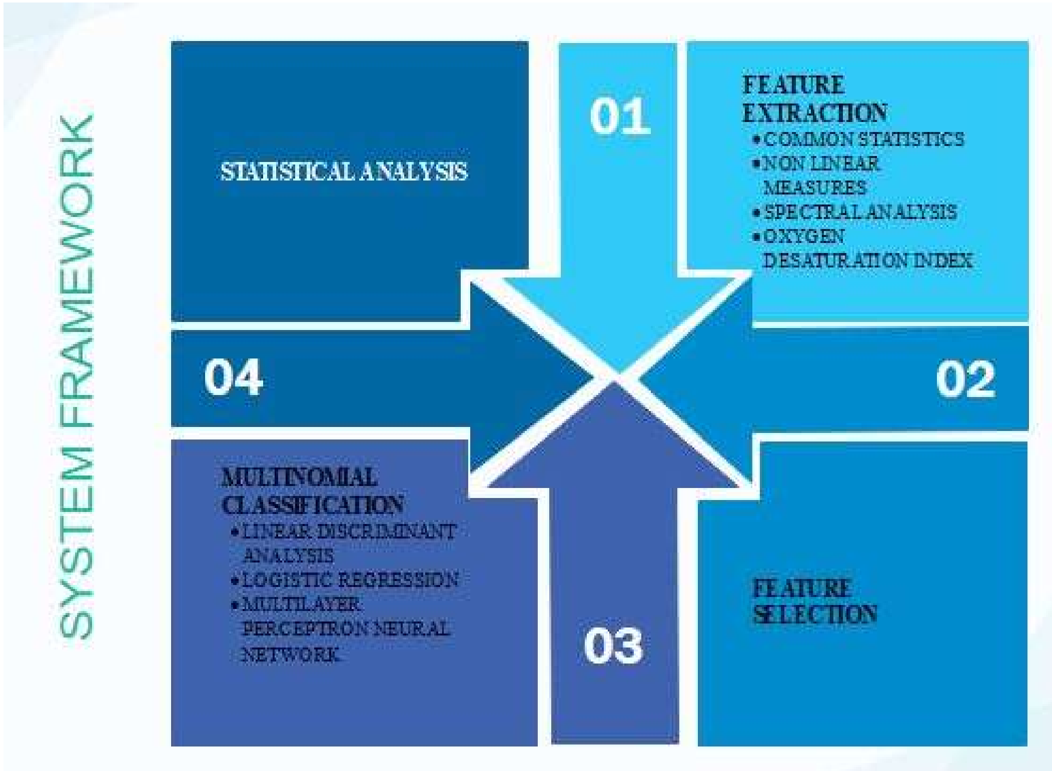

FIG 3: SYSTEM FRAMEWORK