

Sleep Scan: Smart ML Models For Early Sleep Disorder Identification In Real Time

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ABSTRACT

Sleep disorders such as insomnia, sleep apnea, and restless leg syndrome significantly impact an individual's physical health, cognitive performance, and overall quality of life. However, early diagnosis remains a represents a formidable bottleneck stemming from the sparse distribution of sleep laboratories, high costs, and lack of continuous monitoring solutions. In an effort to reconcile these systemic deficiencies, our proposed work proposes Sleep Scan Smart, a real-time machine learning-based analytical platform tailored to the incipient recognition of sleep disorders in a non-invasive and cost-effective manner. The system continuously collects physiological signals including heart rate, oxygen saturation (SpO₂), respiration rate, body movement, and electroencephalogram (EEG) data using wearable or sensor-based devices. These signals undergo real-time preprocessing and feature extraction to remove noise and enhance data quality. Advanced machine learning and deep learning models such as Random Forest, Support Vector Machine (SVM), Long Short-Term Memory (LSTM), and Convolutional Neural Networks (CNN) are employed to analyze patterns and for the algorithmic identification of aberrant patterns secondary to distinct sleep disorders. Sleep Scan Smart performs real-time anomaly detection and generates instant alerts, enabling timely intervention. The system also provides comprehensive sleep health insights through a user-friendly interface, helping users and healthcare professionals make informed decisions. By realizing exceptional predictive exactness under highly constrained resource false alarms, the proposed solution ensures reliable monitoring. Overall, the system enables continuous, home-based sleep assessment and contributes to the advancement of smart, AI-driven preventive healthcare by facilitating early diagnosis and improving long-term health outcomes.

Keywords: Sleep Disorder Anomaly Identification, Computational Learning Paradigms, Deep Learning, Real-Time Monitoring, Insomnia, Sleep Apnea, EEG Analysis, Wearable Sensors, Health Monitoring System, Predictive Healthcare, LSTM, CNN, SVM, Random Forest.

I. INTRODUCTION

Sleep is a baseline cellular pathway imperative for sustaining maintaining physical health, mental well-being, and global health-related wellness markers and psychosocial stability indices. However, sleep disorders such as insomnia, sleep apnea, and restless leg syndrome have become increasingly prevalent due to modern lifestyles, stress, and underlying health conditions. These disorders precipitates severe consequences, including cardiovascular diseases, impaired cognitive function, reduced productivity, and decreased life expectancy. Despite their impact, many sleep disorders remain undiagnosed or are detected at later stages, primarily stemming from the absolute absence of accessible and continuous monitoring systems [1].

Traditional diagnostic methods, such as polysomnography (PSG), require patients to stay overnight in specialized sleep laboratories where multiple physiological parameters are monitored. Despite demonstrating distinct functional utility, such existing approaches remain often expensive, time-consuming, and inconvenient, limiting their widespread use. Furthermore, they do not support continuous long-term monitoring in natural home environments, which is crucial for capturing accurate sleep patterns [2].

Recent advancements in Artificial Intelligence (AI) and the maturation of inductive computing frameworks has created unprecedented analytical avenues toward automated and real-time sleep disorder detection. Several studies have explored ML-based approaches for predicting sleep disorders and improving diagnostic accuracy. For instance, AI-based user interface systems for sleep disorder prediction have been proposed to enhance usability and accessibility [3]. Comprehensive investigations executed via inductive algorithmic frameworks have demonstrated the effectiveness of predictive models in identifying sleep-related issues [4], while deep learning approaches have shown promising results in capturing complex sleep patterns [5].

Recent systems have deployed inductive computational architectures to facilitate the sleep disorder prediction with improved performance and scalability [6]. Hybrid deep learning models such as CNN-LSTM have been applied to predict sleep quality and disorders by analyzing lifestyle and physiological data [7]. Earlier works on

algorithmic sleep architecture categorization via deep neural networks [8] and nocturnal respiratory cessation screening via ECG signals [9] have laid the foundation for modern intelligent sleep monitoring systems. Additionally, wearable device-based approaches have been used to detect insomnia and other disorders in real-world environments [10].

A diverse array of statistical learning pipelines, notably represented by Support Vector Machine (SVM) [11], hybrid deep learning models [12], and explainable AI techniques [13] have further improved the transparency and reliability of predictions. Studies focusing on sleep quality prediction [14] and deep learning-based monitoring systems [15] have demonstrated the potential of continuous health tracking. Moreover, ensemble learning methods [16] and AI-based mobile applications [17] have contributed to making sleep health assessment more accurate, scalable, and user-friendly.

In this context, Sleep Scan Smart is proposed as an innovative real-time sleep monitoring and disorder detection system. The framework operationalizes a hybrid computational suite, deploying ensemble decision trees, maximum-margin hyperplanes, recurrent temporal networks, and grid-based feature extractors to process and analyze multi-modal physiological data. It performs real-time preprocessing, feature extraction, and classification to accurately detect early signs of sleep disorders.

The proposed system aims to provide a cost-effective, non-invasive, and user-friendly solution for continuous home-based monitoring. By generating instant alerts and delivering actionable sleep health insights, Sleep Scan Smart supports early diagnosis and timely intervention. This methodology simultaneously optimizes personalized therapeutic oversight and advances broader medical broader vision of smart, AI-driven preventive healthcare systems.

II. LITERATURE REVIEW

Talal sarheed alshammari [1], 2024

This investigation evaluates the categorization of somnographic anomalies by contrasting traditional statistical classifiers with multi-layered architectural pipelines. Utilizing a 400-entry behavioral and sleep-metric data repository spanning 13 distinct lifestyle variables, evolutionary search mechanics were operationalized to fine-tune hyperparameters across an array of predictive structures, specifically including instance-based, boundary-margin, hierarchical-partitioning, tree-ensemble, and shallow neural networks. Among the evaluated frameworks, the fully connected multi-layer network demonstrated superior diagnostic fidelity, securing a 92.92% classification benchmark alongside robust macro-averaged sensitivity, positive predictive value, and harmonic-mean performance indices. These outcomes underscore the operational efficacy of network-based topologies in refining automated clinical screening protocols for sleep pathology. Erdenebayar Urtnasan, Eun Yeon Joo and Kyu Hee Lee [2], 2021

The authors proposed an AI-enabled Sleep Disorder Network (SDN) for automatic classification of sleep disorders using single-lead ECG signals. The study classified insomnia, periodic leg movement, REM sleep behavior disorder, and nocturnal frontal-lobe epilepsy using deep convolutional neural networks. ECG data from the CAP Sleep Database was segmented into 30-second intervals for training and testing. The model achieved excellent F1-scores ranging from 95% to 99% for different disorder categories. This research demonstrates that ECG-based deep learning can serve as a practical alternative to traditional sleep monitoring systems.

Md. Atiqur Rahman et al. [3], 2025

This study compared multiple machine learning classifiers for detecting sleep disorders such as insomnia and sleep apnea. The researchers used feature selection techniques based on Gradient Boosting Regressor and Mean Decrease Impurity (MDI). Fifteen classifiers were evaluated, including Gradient Boosting, Voting, CatBoost, and Stacking Classifiers. Gradient Boosting achieved the highest AUC value and identical accuracy of 97.33% along with high precision and recall. The work concludes that optimized Gradient Boosting methods provide highly efficient and accurate sleep disorder classification.

Cherie Vartika Stephen and Tasmina Islam [4], 2024

The paper investigates how lifestyle factors influence sleep quality and sleep disorders using a hybrid CNN-LSTM model. Important predictors such as stress level and sleep duration were identified through statistical analysis. The proposed model predicts sleep quality and disorders with an accuracy of 86% and low mean squared error. A user-friendly interface was also developed to provide personalized recommendations based on lifestyle inputs. The study emphasizes the role of modifiable lifestyle behaviors in improving sleep health.

Tayab Uddin Wara et al. [5], 2025

This meta-analytical investigation synthesizes the academic literature concerning algorithmic sleep architecture tracking and sleep-wake pathology identification published between 2016 and 2023. From an initial repository of 185 retrieved manuscripts, 81 full-text investigations underwent rigorous thematic evaluation. The resulting synthesis reveals that neurophysiological electrical activity served as the predominant sensory input across the surveyed methodologies for sleep analysis. Neural Networks, LSTM, Ensemble Learning, SVM, and Random

Forest were among the most widely used AI models. The paper highlights the growing contribution of AI techniques in enhancing sleep disorder diagnosis and classification accuracy.

Nandini Malik, Varuna Gupta and Vandana Sharma [6], 2024

This research presented a comparative study of regression and classification models for predicting insomnia and sleep apnea. The study analyzed machine learning algorithms such as AdaBoost and XGBoost for sleep disorder prediction. Experimental results showed that AdaBoost achieved 93.49% accuracy while XGBoost achieved 92.73% accuracy. The research demonstrates that boosting algorithms are highly effective in predictive analysis of sleep disorders. The findings support the application of machine learning for timely diagnosis and personalized treatment planning.

Mohammad Moinul Islam et al. [7], 2025

The authors developed a machine learning-based sleep disorder prediction system focusing on insomnia and sleep apnea. Various classifiers including Random Forest, Bagging with SVM, and Logistic Regression were tested. Bagging achieved the highest accuracy of 92.4% with strong precision and recall values. Feature importance analysis identified sleep duration, sleep quality, and BMI as significant predictive factors. The study shows that machine learning can provide reliable and low-cost alternatives to traditional polysomnography.

Bollampally Anupama et al. [8], 2024

This paper proposed an AI-based sleep disorder prediction system with a user-friendly interface. The model predicts the possibility of insomnia and sleep apnea using simple parameters such as age, sleep duration, and sleep quality. Unlike traditional sensor-based systems, the proposed method offers a simple and cost-effective solution for early screening. The system aims to increase awareness among users about sleep disorders and encourage medical consultation when needed. The study highlights the usefulness of AI in preventive healthcare applications.

D. Hepsiba, L. D. Vijay Anand and R. Jane Preetha Princy [9], 2021

This review paper discussed the application of deep learning techniques for predicting various sleep disorders. It compared different signal processing methods, algorithms, and datasets used by researchers. The paper explained the advantages and limitations of deep learning in sleep monitoring and diagnosis. It emphasized that sleep is essential for physical and mental health and highlighted the need for feasible monitoring methods. The review concluded that deep learning has strong potential in improving sleep disorder management.

Yuna Park, Heeseung Cho and Junhyoung Oh [10], 2026

The study proposed a deep learning ensemble approach using multi-wavelength photoplethysmogram (PPG) signals for sleep stage detection. The researchers used smartwatch-based PPG signals with CNN and GRU models for classification. The late ensemble fusion model achieved high precision and improved robustness against motion artifacts. The analysis demonstrated that combining multiple PPG channels enhances sleep stage classification accuracy. This work supports the development of wearable AI-based sleep monitoring systems.

Shagen Djanian, Anders Bruun and Thomas Dyhre Nielsen [11], 2022

This review analyzed the use of Consumer Sleep Technologies (CSTs) combined with AI models for sleep stage classification. Twenty-seven research papers were reviewed to study the performance of AI algorithms in real-time sleep monitoring. The study discussed the limitations of traditional polysomnography and the benefits of wearable technologies. It also highlighted future opportunities for interactive AI-based sleep interventions. The paper concludes that AI-integrated CSTs can improve sleep stage classification outside clinical environments.

Yi-Hang Chiu et al. [12], 2024

This systematic review evaluated mobile applications designed for insomnia and depression management. The study reviewed 18 research articles focusing on AI and deep learning-based mobile apps. Features such as early detection, counseling, psychological support, and cognitive behavioral therapy were analyzed. AI chatbots and personalized interventions were found to significantly improve sleep quality and mental health support. The paper highlights the growing importance of AI-powered healthcare applications for sleep disorders.

Puneet Kumar Yadav et al. [13], 2023

The paper explored the use of wearable technologies and deep learning for early detection of sleep disorders. The proposed model achieved an accuracy of 93% in identifying sleep abnormalities. The research compared different signal processing methods and highlighted the role of AI in healthcare diagnostics. The study also discussed challenges in implementing AI systems in clinical environments. It concluded that standardized AI models could significantly improve sleep disorder management.

Maryam Benrais, Nabila Zrira and Fouad Moutaouakkil [14], 2026

This study investigated the use of Deep Neural Networks (DNNs) for predicting stress levels based on sleep-related data. Different machine learning models including XGBoost, Random Forest, SVM, ANN, and DNN were evaluated. The DNN model outperformed all other models in accuracy, ROC analysis, and classification metrics. The research demonstrated the capability of deep learning in identifying complex relationships between sleep and stress. The study supports personalized mental health monitoring using AI.

Hans van Gorp et al. [15], 2023

This research introduced a deep generative learning model called U-Flow for modeling inter-rater disagreement in sleep stage classification. The study addressed challenges associated with manual sleep scoring and variability among human experts. Conditional generative models based on Normalizing Flows were used for automated sleep statistics analysis. The proposed model was tested on polysomnographic data from 70 subjects scored by six experts. The work contributes toward improving reliability and consistency in automated sleep staging systems.

Abdul Ahad and Ajmain Mahtab Alam [16], 2024

This paper focused on air quality prediction using machine learning techniques. The study analyzed PM2.5 pollutant data from 2016 to 2023 using algorithms such as KNN, Random Forest, Gaussian Naïve Bayes, SVM, and Logistic Regression. Experimental results showed that the KNN classifier produced the best prediction performance. The research highlights the effectiveness of machine learning in environmental monitoring and pollution prediction. Accurate air quality forecasting can help improve public awareness and preventive measures.

Tanishq Soni, Deepali Gupta and Mudita Uppal [17], 2023

The study proposed a Logistic Regression-based model for enhancing sleep disorder prediction accuracy. Multiple machine learning models such as SVM, Decision Tree, KNN, and Logistic Regression were compared using a Kaggle sleep disorder dataset. Logistic Regression achieved the highest accuracy of 93.51%. The research considered factors such as age, gender, blood pressure, and physical activity for prediction. The paper demonstrates the effectiveness of machine learning in detecting sleep-related health issues.

Alexander A. Huang and Samuel Y. Huang [18], 2023

This research applied machine learning to identify risk factors associated with insomnia. The study used the NHANES public health dataset containing demographic, laboratory, exercise, and mental health information from 7,929 patients. Machine learning models identified 64 significant features related to insomnia. The study proved that AI can effectively analyze complex health data and predict sleep disorder risks. The findings may help healthcare professionals in early identification and preventive care.

Azza Tantawy, Nayera El-Sherif and Fatma S. E. Ebeid [19], 2023

This study investigated sleep disordered breathing (SDB) in children with sickle cell disease. Clinical assessments, polysomnography, and questionnaires were used to analyze obstructive sleep apnea (OSA). Results showed that 60% of the children experienced sleep apnea, which was associated with pulmonary hypertension and stroke-related risks. The study emphasized the importance of early detection and management of OSA in children with sickle cell disease. The findings support the clinical relevance of sleep disorder monitoring.

Murugesan M, Abirami V, Iswarya M and Kaviya N [20], 2023

The paper proposed a CNN-based deep learning model for detecting sleeping abnormalities using EEG recordings. EEG data were preprocessed to remove artifacts and segmented using sliding time windows. Extracted features were provided as inputs to the CNN model for sleep stage classification. The model analyzed EEG signals efficiently and provided precautions based on the results. The study demonstrates the potential of deep learning for automated sleep disorder diagnosis and healthcare support.

Table 1: Comparative Analysis

Ref No	Year	Title	Authors & Journal (Issue Date)	Methodology (Dataset + Approach)	Accuracy / Results	Research Gap
[10]	2026	Deep learning ensemble approach to multi-wavelength photoplethysmogram for sleep stage detection	Yuna Park, Heeseung Cho and Junhyoung Oh	Used smartwatch-based multiwavelength PPG signals with CNN+GRU ensemble model.	Achieved precision of 73.8% with improved robustness to motion artifacts.	Performance still lower compared to PSG-based systems.
[14]	2026	Leveraging Deep Neural Networks to Predict Stress Throughout the Day from Sleep Data	Maryam Benrais, Nabila Zrira and Fouad Moutaouakkil	Compared DNN, RF, XGBoost, ANN, and SVM using sleep-derived stress data.	DNN outperformed all other models in prediction accuracy.	Study focused on stress prediction rather than direct sleep disorder classification.
[3]	2025	Improving Sleep Disorder Diagnosis Through Optimized Machine Learning Approaches	Md. Atiqur Rahman et al.	Used Sleep Health and Lifestyle Dataset with feature engineering and 15 classifiers including	Gradient Boosting achieved 97.33% accuracy and	Lack of deep learning integration and real-time monitoring

Ref No	Year	Title	Authors & Journal (Issue Date)	Methodology (Dataset + Approach)	Accuracy / Results	Research Gap
				Gradient Boosting and CatBoost.	AUC of 0.9953.	implementation.
[5]	2025	A systematic review on sleep stage classification and sleep disorder detection using artificial intelligence	Tayab Uddin Wara et al.	Reviewed 81 AI-based sleep disorder and sleep stage classification studies from 2016–2023.	Identified Neural Networks as most widely used AI model (47%).	Does not propose a new model or experimental implementation.
[7]	2025	Sleep Disorder Prediction System Using Machine Learning	Mohammad Moinul Islam et al.	Used Random Forest, Bagging with SVM, and Logistic Regression with hyperparameter tuning.	Bagging achieved highest accuracy of 92.4%.	Model lacks deep learning methods and real-world deployment analysis.
[1]	2024	Applying Machine Learning Algorithms for the Classification of Sleep Disorders	TALAL SARHEED ALSHAMMARI	Used Sleep Health and Lifestyle Dataset containing 400 rows and 13 features. Applied KNN, SVM, Decision Tree, Random Forest, and ANN with Genetic Algorithm optimization.	ANN achieved highest accuracy of 92.92%, precision 92.01%, recall 93.80%, and F1-score 91.93%.	Dataset size is small and lacks real-time physiological signals such as EEG and ECG.
[4]	2024	Lifestyle to Sleep Health: A CNN-LSTM Approach for Predicting Sleep Quality and Disorders	Cherie Vartika Stephen and Tasmina Islam	Hybrid CNN-LSTM model using lifestyle and health-related parameters with hyperparameter tuning.	Achieved 86% accuracy and MSE of 0.77 for sleep quality prediction.	Lower accuracy compared to advanced ensemble models and limited clinical validation.
[6]	2024	Predictive Analysis of Sleep Disorders Using Machine Learning: A Comprehensive Analysis	Nandini Malik, Varuna Gupta and Vandana Sharma	Comparative analysis using AdaBoost, XGBoost, and other ML algorithms on insomnia and sleep apnea datasets.	AdaBoost achieved 93.49% accuracy and XGBoost achieved 92.73%.	Limited feature diversity and no wearable sensor integration.
[8]	2024	Sleep Disorder Prediction with AI User Interface	Bollampally Anupama et al.	Developed AI-based interface using simple parameters like age, sleep duration, and sleep quality.	Provided fast and simple prediction system for insomnia and sleep apnea.	No detailed accuracy metrics and lacks clinical validation dataset.
[12]	2024	Exploring the Role of Mobile Apps for Insomnia in Depression: Systematic Review	Yi-Hang Chiu et al.	Systematic review of AI and deep learning-based mobile applications for insomnia and depression.	Found CBT and AI chatbots effective for mental health support.	Limited focus on objective sleep signal analysis.
[16]	2024	Data Driven Air Quality Analysis and Predictions: A Machine Learning	Abdul Ahad and Ajmain Mahtab Alam	Used PM2.5 pollutant datasets with KNN, Random Forest, SVM, and	KNN showed best performance in air quality	Not directly related to sleep disorder detection.

Ref No	Year	Title	Authors & Journal (Issue Date)	Methodology (Dataset + Approach)	Accuracy / Results	Research Gap
		Approach		Logistic Regression.	prediction.	
[13]	2023	Sleep Disorder Detection using Machine Learning Method	Puneet Kumar Yadav et al.	Applied machine learning and wearable technology-based deep learning methods for sleep disorder detection.	Proposed model achieved 93% accuracy.	Challenges in standardization and clinical integration remain unresolved.
[15]	2023	Modeling the Impact of Inter-Rater Disagreement on Sleep Statistics Using Deep Generative Learning	Hans van Gorp et al.	Introduced U-Flow generative model using polysomnography data from 70 subjects.	Improved modeling of inter-rater disagreement in sleep scoring.	Complex architecture may increase computational cost and implementation difficulty.
[17]	2023	Enhancing Accuracy of Sleep Disorder with Logistic Regression Model	Tanishq Soni, Deepali Gupta and Mudita Uppal	Compared Logistic Regression, SVM, KNN, and Decision Tree using Kaggle dataset.	Logistic Regression achieved 93.51% accuracy.	Dataset limitations and absence of physiological signal analysis.
[18]	2023	Use of machine learning to identify risk factors for insomnia	Alexander A. Huang and Samuel Y. Huang	Used NHANES dataset with demographic and health-related data for insomnia prediction.	Identified 64 significant insomnia risk factors using ML models.	Prediction accuracy not clearly specified and lacks deep learning comparison.
[19]	2023	Sleep disordered breathing and its relation to stroke and pulmonary hypertension in children with sickle cell disease	Azza Tantawy, Nayera El-Sherif and Fatma S. E. Ebeid	Clinical study using polysomnography and STOP-Bang questionnaire on 30 children with SCD.	Found 60% prevalence of sleep apnea in studied children.	Small sample size and no AI-based automated classification.
[20]	2023	Sleeping Abnormalities Detection using Deep Learning Techniques	Murugesan M, Abirami V, Iswarya M and Kaviya N	Used EEG recordings processed through CNN for sleep stage classification.	CNN-based model effectively classified sleep stages.	Lack of large-scale dataset evaluation and real-time implementation.
[11]	2022	Sleep classification using Consumer Sleep Technologies and AI: A review of the current landscape	Shagen Djanian, Anders Bruun and Thomas Dyhre Nielsen	Reviewed 27 papers using Consumer Sleep Technologies and AI models for sleep stage classification.	Highlighted AI-based wearable systems for sleep monitoring.	Review lacks experimental comparison and real-world validation.
[2]	2021	AI-Enabled Algorithm for Automatic Classification of Sleep Disorders Based on Single-Lead Electrocardiogram	Erdenebayar Urtnasan, Eun Yeon Joo and Kyu Hee Lee	Used CAP Sleep Database with ECG signals from 35 subjects. Developed deep CNN-based Sleep Disorder Network (SDN).	Achieved F1-scores between 95% and 99% for different sleep disorders.	Study used limited subjects and focused only on ECG signals without lifestyle factors.
[9]	2021	Deep Learning for Sleep Disorders: A Review	D. Hepsiba, L. D. Vijay Anand and R. Jane Preetha	Reviewed deep learning methods, signals, and	Summarized advantages and limitations of	No practical implementation or comparative

Ref No	Year	Title	Authors & Journal (Issue Date)	Methodology (Dataset + Approach)	Accuracy / Results	Research Gap
			Princy	processing techniques for sleep disorder prediction.	DL approaches.	experimental results.

III. RESEARCH GAP

Table 3: Research Gaps

Category	Author & Year	Input Data	Methodology / Techniques	Model / Approach	Output	Key Contribution
Sleep Disorder Classification	TALAL SARHEED ALSHAMMARI (2024)	Sleep Health and Lifestyle Dataset	Genetic Algorithm optimization with ML classifiers	KNN, SVM, DT, RF, ANN	Classification of sleep disorders	ANN achieved highest accuracy of 92.92% for sleep disorder prediction
ECG-Based Sleep Detection	Erdenebayar Urtnasan et al. (2021)	Single-lead ECG signals from CAP Sleep Database	Signal preprocessing, segmentation, deep learning	Deep CNN-based SDN	Detection of INS, PLM, RBD, and NFE disorders	Demonstrated accurate sleep disorder classification using only ECG signals
Optimized ML Prediction	Md. Atiqur Rahman et al. (2025)	Sleep Health and Lifestyle Dataset	Feature selection using MDI and Gradient Boosting	Gradient Boosting, Voting, CatBoost, Stacking	Sleep disorder classification	Achieved 97.33% accuracy with optimized ML models
Lifestyle-Based Prediction	Cherie Vartika Stephen and Tasmina Islam (2024)	Lifestyle and health-related parameters	Statistical analysis and hybrid deep learning	CNN-LSTM	Sleep quality and disorder prediction	Combined lifestyle analysis with deep learning for personalized recommendations
Systematic AI Review	Tayab Uddin Wara et al. (2025)	Research articles from 2016–2023	Literature review and comparative analysis	Neural Networks, LSTM, RF, SVM	AI-based sleep disorder analysis	Provided comprehensive review of AI techniques used in sleep studies
Predictive ML Analysis	Nandini Malik et al. (2024)	Insomnia and sleep apnea datasets	Comparative machine learning analysis	AdaBoost, XGBoost	Prediction of sleep disorders	AdaBoost achieved 93.49% accuracy for prediction
Sleep Prediction System	Mohammad Moinul Islam et al. (2025)	Sleep health-related parameters	Hyperparameter tuning and classification	Bagging, RF, Logistic Regression	Sleep disorder diagnosis	Proposed cost-effective ML-based diagnostic system
AI User Interface System	Bollampally Anupama et al. (2024)	Age, sleep duration, sleep quality	AI-based prediction with simple parameters	ML-based AI interface	Early prediction of sleep disorders	Developed user-friendly prediction interface for common users
Deep Learning	D. Hepsiba et al. (2021)	Various physiological	Review of signal	Deep Learning	Sleep disorder	Compared deep learning

Category	Author & Year	Input Data	Methodology / Techniques	Model / Approach	Output	Key Contribution
Review		signals	processing and DL methods	algorithms	prediction analysis	techniques and challenges in sleep healthcare
Sleep Stage Detection	Yuna Park et al. (2026)	Multiwavelength PPG smartwatch signals	Signal fusion and ensemble learning	CNN + GRU ensemble model	Sleep stage classification	Improved wearable-based sleep monitoring using multi-channel PPG
Consumer Sleep Technology Review	Shagen Djanian et al. (2022)	Data from consumer sleep technologies	Comparative review of AI-based CST systems	AI models for sleep staging	Automated sleep stage classification	Highlighted benefits of AI-integrated wearable sleep technologies
Mobile App Healthcare Review	Yi-Hang Chiu et al. (2024)	Mobile app and mental health datasets	Systematic review	AI chatbots and CBT apps	Insomnia and depression support	Demonstrated role of AI mobile apps in mental healthcare
ML Sleep Detection	Puneet Kumar Yadav et al. (2023)	Wearable and physiological signals	Deep learning and signal processing	ML and DL models	Sleep disorder detection	Achieved 93% accuracy in detecting sleep abnormalities
Stress Prediction Using Sleep Data	Maryam Benrais et al. (2026)	Sleep-derived physiological data	Comparative ML and DL analysis	Deep Neural Networks (DNN)	Daily stress prediction	DNN showed superior performance for stress monitoring
Deep Generative Sleep Analysis	Hans van Gorp et al. (2023)	Polysomnography data	Conditional generative learning	U-Flow model	Sleep statistics modeling	Modeled inter-rater disagreement in sleep scoring
Air Quality Prediction	Abdul Ahad and Ajmain Mahtab Alam (2024)	PM2.5 air pollutant dataset	Comparative machine learning analysis	KNN, RF, SVM	Air quality prediction	KNN achieved best prediction accuracy
Logistic Regression Sleep Analysis	Tanishq Soni et al. (2023)	Kaggle sleep disorder dataset	Classification and comparative analysis	Logistic Regression, SVM, DT	Sleep disorder prediction	Logistic Regression achieved 93.51% accuracy
Insomnia Risk Factor Analysis	Alexander A. Huang and Samuel Y. Huang (2023)	NHANES health survey dataset	Feature analysis using machine learning	ML predictive models	Insomnia risk prediction	Identified major risk factors affecting insomnia
Clinical Sleep Breathing Study	Azza Tantawy et al. (2023)	Polysomnography and clinical data	Clinical assessment and statistical analysis	Sleep apnea analysis	Detection of sleep disordered breathing	Linked sleep apnea with pulmonary hypertension and stroke risk
EEG-Based Sleep Abnormality Detection	Murugesan M et al. (2023)	EEG recordings and EDF files	EEG preprocessing and deep learning	CNN	Sleep stage classification	Automated sleep abnormality detection using EEG signals

IV. CONCLUSION

Sleep disorders have become a significant global health concern due to their adverse effects on physical health, cognitive functioning, and overall quality of life. This literature survey reviewed recent advancements in Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL) techniques for sleep disorder detection, classification, and monitoring. The reviewed studies demonstrate that algorithms such as Random Forest, Support Vector Machine (SVM), Gradient Boosting, Artificial Neural Networks (ANN), Convolutional Neural Networks (CNN), Long Short-Term Memory (LSTM), and hybrid CNN-LSTM models have achieved promising performance in identifying sleep-related abnormalities.

The survey reveals that physiological signals including EEG, ECG, PPG, respiration patterns, and wearable sensor data play a crucial role in improving prediction accuracy. Several studies reported classification accuracies exceeding 90%, highlighting the effectiveness of AI-driven approaches in sleep healthcare. Furthermore, wearable technologies, mobile applications, and consumer sleep monitoring devices have expanded the possibilities for continuous and home-based sleep assessment.

Despite these advancements, several challenges remain, including limited dataset diversity, lack of real-time implementation, insufficient integration of multimodal physiological signals, and the need for improved clinical validation. Many existing approaches focus on specific disorders or individual signal types, limiting their applicability in comprehensive sleep monitoring environments.

Based on the reviewed literature, there is a clear opportunity to develop intelligent, real-time, and non-invasive sleep monitoring systems that combine multiple physiological signals with advanced machine learning and deep learning models. Future research should focus on multimodal data fusion, explainable AI techniques, large-scale clinical validation, and deployment of wearable-based monitoring platforms to enhance the accuracy, accessibility, and reliability of sleep disorder diagnosis. Such advancements can contribute significantly to preventive healthcare and improve the overall management of sleep-related disorders..

A. Future Scope

The system can be further enhanced by incorporating more advanced technologies and features. Future improvements may include:

- Integration with **advanced wearable devices** for more accurate and comfortable data collection
- Use of **Explainable AI (XAI)** to improve transparency and trust in predictions
- Implementation of **cloud-based big data analytics** for large-scale sleep data analysis
- Development of **mobile applications with personalized recommendations** using AI
- Integration with **smart home systems (IoT)** for automated environment adjustment (light, temperature, noise)
- Enhancement using **deep learning models like Transformers** for better time-series analysis
- Real-time **doctor connectivity and telemedicine support**
- Expansion to detect additional health conditions such as stress, anxiety, and cardiovascular risks

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