IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 11, April 2026
Impact Factor: 8.2

Sleep Disorder Detection System

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Abstract: *Sleep disorders have become increasingly prevalent in modern society due to factors such as stress, unhealthy lifestyles, and irregular sleep patterns, significantly affecting both physical and mental health. Conditions such as sleep apnea, insomnia, and narcolepsy not only reduce sleep quality but also lead to serious health complications, including cardiovascular diseases, reduced cognitive performance, and decreased productivity. Traditional diagnostic methods, such as polysomnography, are often expensive, time-consuming, and require specialized medical infrastructure, making early detection difficult for a large population. This research presents a Sleep Disorder Detection System that utilizes machine learning techniques to provide a cost-effective and efficient solution for the early identification of multiple sleep disorders*

Keywords: Machine Learning, Sleep Disorder, Django, Prediction, SVM, Random Forest

I. INTRODUCTION

The Sleep Disorder Detection System is an AI-based research project developed to analyze human sleep patterns using data sourced entirely from public Kaggle repositories. It aims to automatically identify irregularities associated with conditions such as insomnia, sleep apnea, and poor sleep efficiency through computational modeling. Sleep, a critical physiological process, directly affects mental clarity, metabolic balance, and cardiovascular health. When disrupted, it can lead to chronic fatigue, mood disorders, and serious long-term illnesses. Traditional diagnostics like polysomnography (PSG), though reliable, are expensive, require specialized equipment, and must be conducted overnight in clinical facilities. To overcome these limitations, this project uses machine learning (ML) and deep learning (DL) techniques on open-access Kaggle datasets containing photoplethysmogram (PPG) and related physiological variables. By analyzing these curated datasets, the system simulates real-world detection scenarios without the complexity of live data acquisition. Future iterations will extend the same algorithms to process wearable data streams in real time, but the current implementation remains strictly dataset-based to ensure reproducibility and accessibility for academic research.

The system ingests PPG recordings, applies a signal-processing pipeline (denoising, bandpass filtering, peak detection, segmentation), performs feature extraction and clustering for interpretability, and uses neural-network classification to label segments as normal or abnormal.

II. RELATED WORK

In recent years, significant research has been conducted in the field of sleep apnea detection using various computational and medical approaches. Early studies focused on physiological signal analysis, particularly electrocardiogram (ECG) and blood oxygen saturation levels, to identify apnea events. Researchers developed algorithms capable of detecting irregular heart rate patterns and oxygen fluctuations associated with sleep apnea. These methods achieved moderate to high accuracy, ranging between 80% and 90%, depending on the dataset and approach used.

Further advancements introduced machine learning techniques such as K-Nearest Neighbors (KNN), Support Vector Machines (SVM), and Artificial Neural Networks (ANN). These models improved prediction accuracy by learning patterns from historical patient data. Some studies reported accuracy levels exceeding 95% when using optimized

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feature selection techniques and hybrid models. Additionally, wearable sensor-based systems were proposed to enable real-time monitoring of patients, offering convenience and continuous data collection.

Despite these advancements, several limitations persist in existing systems. Many approaches rely heavily on specialized medical equipment, making them costly and less accessible. Additionally, most systems lack user-friendly interfaces, limiting their usability for non-technical users. There is also a dependency on large and complex datasets, which may not always be available. These challenges highlight the need for a simplified, cost-effective, and user-centric solution, which this research aims to address through a web-based machine learning system.

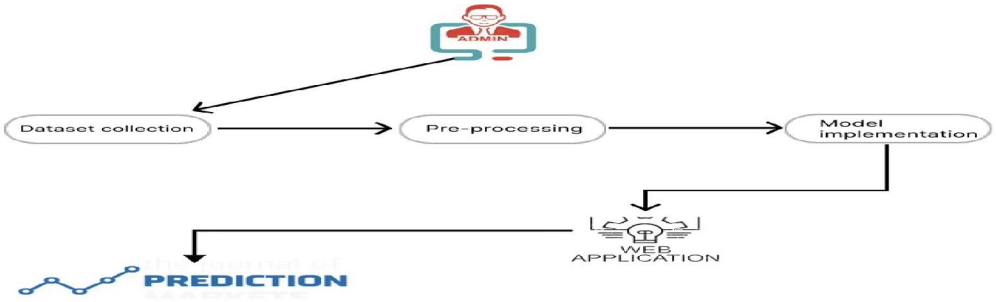

Fig. 1 Proposed System Workflow for Sleep Disorder

III. METHODOLOGY

The proposed system is designed to detect sleep apnea using a combination of machine learning techniques and web-based technologies. The methodology involves several stages, including data collection, preprocessing, model training, and deployment through a web application. The first step involves collecting a dataset containing patient health parameters such as age, BMI, breathing patterns, and other relevant features. This data serves as the foundation for training the machine learning models. Once the dataset is obtained, preprocessing techniques are applied to clean and prepare the data. This includes handling missing values, removing noise, and normalizing the data to ensure consistency and accuracy during model training.

In the next stage, machine learning algorithms such as Random Forest and Support Vector Machine (SVM) are implemented. These algorithms are selected due to their ability to handle classification problems effectively and provide high accuracy. The models are trained using the processed dataset and evaluated based on their performance metrics. Once trained, the best-performing model is saved and integrated into the system.

To make the system accessible to users, a web application is developed using the Django framework. This application allows users to input their symptoms and relevant health information through a simple interface. The input data is then processed by the trained machine learning model, which predicts whether the user is likely to have sleep apnea. The result is displayed instantly, providing users with a quick and convenient diagnostic tool. Since this project is data-centric and AI-driven, it does not follow a purely linear SDLC like the traditional Waterfall model. Instead, it adopts an Agile–Iterative approach suited for machine learning projects that involve repetitive experimentation, model refinement, and dataset validation using Kaggle-based data sources.

FEATURES OF THE PROPOSED SYSTEM

The proposed Sleep Disorder Detection System is designed to provide an efficient, scalable, and user-friendly solution for identifying multiple sleep-related disorders using machine learning and web technologies. One of the key features of the system is its ability to detect and analyze various sleep disorders such as sleep apnea, insomnia, and narcolepsy. Unlike traditional systems that focus on a single condition, this system provides a broader and more comprehensive approach to sleep health analysis.

Another important feature of the system is the use of advanced machine learning algorithms, including Random Forest and Support Vector Machine (SVM), which are capable of processing complex medical data and identifying patterns

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associated with different sleep disorders. These models are trained on structured datasets and are optimized to deliver accurate and reliable predictions based on user input. The system is also equipped with a user-friendly web interface developed using the Django framework. This interface allows users to easily enter their symptoms and relevant health information without requiring any technical expertise. The simplicity of the interface ensures accessibility for a wide range of users, including individuals with minimal technical knowledge.

In addition, the system provides real-time prediction capabilities, enabling users to receive instant results after submitting their data. This significantly reduces the time required for preliminary diagnosis compared to traditional healthcare methods. The system also includes a secure database, implemented using MySQL, which stores user inputs, prediction results, and system logs for future reference and analysis.

Furthermore, the system follows a modular architecture, where different components such as data preprocessing, model training, and prediction operate independently. This enhances the maintainability and scalability of the system, allowing future improvements such as adding new disorders or upgrading algorithms. The system also incorporates data validation and security measures to ensure the accuracy and protection of user data.

BENEFITS OF THE PROPOSED SYSTEM

The Sleep Disorder Detection System offers numerous benefits that make it a valuable tool in modern healthcare and preventive medicine. One of the primary advantages of the system is its cost-effectiveness. Traditional diagnostic methods for sleep disorders, such as sleep studies and polysomnography, are expensive and require specialized equipment. In contrast, the proposed system provides an affordable alternative that can be accessed through a simple web application.

Another major benefit is improved accessibility. Since the system is web-based, users can access it anytime and from anywhere using a computer or mobile device. This is especially beneficial for individuals in remote or rural areas where access to healthcare facilities is limited. The system enables early detection of sleep disorders, allowing users to take timely medical action.

The system also enhances efficiency by providing instant predictions. Traditional diagnostic procedures can take several hours or days, whereas this system delivers results in real time. This reduces waiting time and improves the overall user experience.

In addition, the use of machine learning algorithms improves the accuracy and reliability of predictions. These models can analyze large amounts of data and detect patterns that may not be easily identified through manual methods. As a result, the system provides more consistent and data-driven outcomes.

Overall, the proposed system provides a powerful combination of technology and healthcare, offering a solution that is efficient, scalable, and user-centric. It not only simplifies the detection of sleep disorders but also contributes to improving overall health and quality of life.

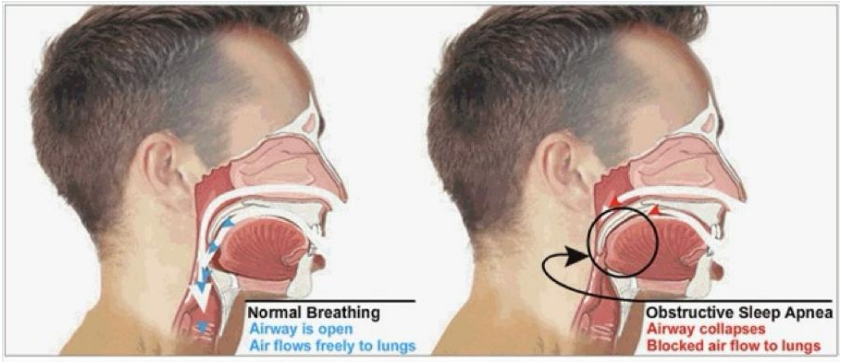

Fig. 2 A Figure showing Sleep Apnea

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Types of Sleep Disorders

Fig. 3 Types of Sleep Disorder

Sleep Apnea: It is a sort of sleep disorder defined by stops in breathing or infrequent breathing amid sleep. Every stop in breathing known as apnea that can retain from no less than ten seconds to minutes and may happen 5 to 30 times or increasingly 60 minutes. Fundamentally, sleep apnea is a sleep-related breathing disorder. The below Figure 4 demonstrates the consequences of sleep apnea.

Insomnia: The presence of this disorder happened regularly in OSA patients and consistently related with poor sleep quality yet had no impact on long-haul 7 inconveniences and as indicated the half patients experienced insomnia which goes from moderate to serious.

Parasomnia: It refers to physical disturbance during sleep that involves the skeletal, motor and autonomic nervous systems. Adults with parasomnia often report the behavioral, perceptual, emotional, and dreamlike disturbances that may erroneously suggest a psychiatric disorder

Snoring: It is a sound delivered because of obscured air movement amid breathing during sleep. Sometimes, this sound might be delicate, however in different cases; it can be heavy and undesired.

IV. SYSTEM IMPLEMENTATION

1 System Overview

The Sleep Disorder Detection System is implemented using a combination of machine learning techniques and web-based technologies to provide an efficient and accessible platform for detecting multiple sleep disorders. The system is developed using Python due to its strong support for data analysis and machine learning libraries. The web interface is built using the Django framework, which follows the Model-View-Template architecture and ensures smooth interaction between the user interface, backend logic, and database. MySQL is used for data storage, enabling structured management of user information and prediction results. The system is designed in a modular manner to ensure scalability, flexibility, and ease of maintenance.

2 User Registration and Authentication Module

The user registration and authentication module is responsible for managing user access and ensuring data security within the system. New users are required to register by providing basic details such as name, email address, and password. The system performs validation checks to ensure the correctness and format of the entered data. Passwords are securely stored in encrypted form to prevent unauthorized access. Once registered, users can log in using their credentials and access the system features. This module ensures that only authenticated users can use the prediction system, thereby maintaining data privacy and system integrity.

3 Data Collection and Input Module

The data collection module allows users to input relevant health and lifestyle information required for sleep disorder prediction. The system provides a user-friendly interface where individuals can enter parameters such as sleep duration, fatigue level, breathing irregularities, snoring habits, and stress levels. These input features are essential for analyzing

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the user's sleep condition. The module is designed to ensure simplicity and ease of use so that even non-technical users can interact with the system without difficulty.

4 Data Preprocessing Module

The data preprocessing module plays a crucial role in preparing the collected data for machine learning analysis. Raw input data may contain inconsistencies, missing values, or noise that can affect model performance. Therefore, preprocessing techniques such as data cleaning, normalization, and transformation are applied to ensure data quality. This module ensures that the input data is in a suitable format for the machine learning models, thereby improving prediction accuracy and reliability.

5 Machine Learning Model Implementation

The machine learning model implementation module is the core component of the system, where classification algorithms are used to detect sleep disorders. The system utilizes algorithms such as Random Forest and Support Vector Machine (SVM), which are known for their effectiveness in handling classification problems. These models are trained using preprocessed datasets and evaluated based on performance metrics such as accuracy and precision. The best-performing model is selected and stored for deployment in the system. This module enables the system to learn patterns from data and make intelligent predictions.

6 Prediction Module

The prediction module is responsible for generating results based on user input. When a user submits their data through the web interface, the system processes the input and feeds it into the trained machine learning model. The model analyzes the input parameters and predicts the type of sleep disorder, such as sleep apnea, insomnia, or narcolepsy. The prediction process is performed in real time, ensuring that users receive immediate feedback regarding their condition.

7 Result Visualization Module

The result visualization module presents the prediction outcome to the user in a clear and understandable manner. The system displays whether the user is likely to have a specific sleep disorder along with a brief explanation. In some cases, graphical representations such as charts or indicators may be used to enhance clarity. This module ensures that users can easily interpret the results and take appropriate actions if necessary.

8 Database Management Module

The database management module handles the storage and retrieval of all system-related data. The MySQL database is used to store user details, input parameters, prediction results, and system logs. This structured storage enables efficient data management and supports future analysis and model improvements. The database also ensures data consistency and integrity throughout the system.

9 Security and Data Validation

Security and data validation are essential components of the system implementation. The system includes validation checks to ensure that user inputs are accurate and within acceptable limits. Additionally, secure authentication mechanisms and encrypted password storage are implemented to protect user data. These measures help prevent unauthorized access and ensure the confidentiality and integrity of sensitive information.

V. RESULTS AND DISCUSSION

The performance of the Sleep Disorder Detection System was evaluated using a structured dataset along with simulated user inputs to analyze its effectiveness in predicting various sleep disorders. The system was tested with multiple combinations of input parameters such as sleep duration, fatigue levels, breathing irregularities, snoring patterns, and stress conditions. Based on these inputs, the machine learning models were able to process the data efficiently and generate predictions in real time. The results indicate that the system is capable of identifying meaningful patterns within the data and accurately classifying users into different categories of sleep disorders, including sleep apnea, insomnia, and narcolepsy.

The machine learning algorithms used in the system, namely Random Forest and Support Vector Machine (SVM), demonstrated strong performance in classification tasks. The Random Forest algorithm showed slightly better accuracy

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due to its ensemble learning nature, which combines multiple decision trees to improve prediction reliability and reduce overfitting. On the other hand, the Support Vector Machine provided consistent and stable results, particularly in cases where the data was clearly separable. The use of proper data preprocessing techniques, including normalization and handling of missing values, significantly contributed to the overall accuracy and reliability of the predictions.

When compared to traditional diagnostic methods such as polysomnography, the proposed system offers several advantages. Traditional methods require expensive equipment, overnight monitoring, and expert supervision, making them time-consuming and less accessible to a large population. In contrast, the Sleep Disorder Detection System provides a fast and cost-effective alternative by delivering instant predictions through a web-based interface. Although the system does not replace clinical diagnosis, it serves as an efficient preliminary screening tool that can help users identify potential sleep disorders and seek further medical advice when necessary.

The results obtained from the system highlight the potential of machine learning in healthcare applications, particularly in the early detection and monitoring of sleep disorders. The system not only simplifies the diagnostic process but also increases awareness among users regarding their health conditions. However, certain limitations exist, such as dependency on the quality of the training dataset and the accuracy of user-provided inputs. Inaccurate or incomplete data may affect the prediction results. Therefore, the system should be considered as a supportive tool rather than a replacement for professional medical evaluation.

Overall, the Sleep Disorder Detection System demonstrates promising performance and provides a practical solution for early detection of sleep disorders. With further improvements such as integration of real-time data, advanced deep learning models, and mobile-based deployment, the system can be enhanced to provide even more accurate and comprehensive healthcare solutions.

VI. CONCLUSION

This research presents a machine learning-based approach for detecting obstructive sleep apnea using a Django-based web application. The system addresses the limitations of traditional diagnostic methods by providing a cost-effective, efficient, and accessible solution for early detection. By leveraging machine learning algorithms, the system is able to analyze patient data and generate accurate predictions, while the web interface ensures ease of use for non-technical users. The integration of technology in healthcare has the potential to revolutionize disease detection and management. This system demonstrates how machine learning and web development can be combined to create practical solutions for real-world problems. The proposed approach not only improves diagnostic efficiency but also contributes to increased awareness and better healthcare outcomes.

VII. FUTURE SCOPE

The Sleep Disorder Detection System presented in this research provides an efficient and accessible approach for identifying sleep-related disorders; however, there remains significant scope for further enhancement and development to make the system more advanced, accurate, and suitable for real-world healthcare applications. One of the primary directions for future work is the integration of real-time data collection through wearable devices such as smartwatches and fitness trackers. These devices can continuously monitor physiological parameters such as heart rate, oxygen saturation levels, and sleep patterns, enabling the system to perform continuous analysis and provide more accurate and dynamic predictions based on real-time data rather than static user inputs.

The system can also be extended into a mobile-based application to increase accessibility and usability. A mobile platform would allow users to monitor their sleep health conveniently from anywhere and at any time. Features such as real-time notifications, personalized health recommendations, and daily or weekly sleep reports can be integrated to improve user engagement and promote proactive health management. Furthermore, deploying the system on cloud infrastructure can enable scalable data storage and faster processing, making it suitable for large-scale usage.

Integration with healthcare systems and electronic health records is another promising direction for future development. By connecting the system with hospital databases, doctors and healthcare professionals can access patient data, analyze

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trends, and provide better clinical recommendations. This integration can also support telemedicine services, allowing remote consultation and reducing the need for physical visits to healthcare facilities, especially in remote or underserved regions.

Finally, the scope of the system can be expanded beyond the detection of sleep apnea, insomnia, and narcolepsy to include other sleep disorders and related health conditions. By increasing the range of detectable disorders and continuously improving the dataset, the system can evolve into a comprehensive sleep health monitoring platform. With continuous advancements in technology and further research, the proposed system has the potential to become a reliable and widely used tool in modern healthcare for early detection and prevention of sleep-related disorders.

VIII. ACKNOWLEDGEMENT

The successful completion of this research work would not have been possible without the guidance, support, and encouragement of several individuals and institutions. We would like to express our sincere gratitude to our respected project guide and faculty members of the Department of Computer Science and Engineering for their continuous support, valuable suggestions, and constructive feedback throughout the development of this project. Their expertise and insights played a crucial role in shaping the direction of this research and improving its overall quality.

We are also deeply thankful to our institution for providing us with the necessary infrastructure, technical resources, and a conducive learning environment that enabled us to carry out this work efficiently. The availability of tools, laboratories, and academic support greatly contributed to the successful implementation of our system. Furthermore, we would like to extend our appreciation to our peers and colleagues who provided constant motivation, shared ideas, and assisted us during various stages of the project. Their collaborative spirit and encouragement helped us overcome challenges and complete this work successfully.

We also acknowledge the contributions of the open-source community and the developers of technologies such as Python, Django, and machine learning libraries, which made it possible to design and implement this system effectively. Finally, we express our heartfelt gratitude to our family members for their unwavering support, patience, and encouragement throughout the entire duration of this research work.

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