IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 1, January 2026

DOI: 10.17148/IJARCCE.2026.15153

SLEEP DISORDER PREDICTION

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Abstract: This paper presents a machine learning–based Sleep Disorder Prediction System designed to assist in the early identification and awareness of common sleep-related disorders. The system analyzes user-provided health and lifestyle parameters such as sleep duration, body mass index (BMI), stress level, physical activity, heart rate, and blood pressure to predict sleep conditions including Healthy, Insomnia, and Sleep Apnea. By integrating a trained classification model with a Django-based web application, the system provides real-time predictions along with confidence scores to help users better understand their sleep health status. The platform also includes features such as user authentication, prediction history tracking, doctor appointment booking, and contact support, making it practical for real-world usage. This approach demonstrates how data-driven machine learning techniques can offer an accessible, cost-effective, and user-friendly solution for preliminary sleep disorder assessment and promote proactive sleep health management.

Keywords: Sleep Disorder Prediction, Machine Learning, Insomnia, Sleep Apnea, Healthcare Analytics, Web Application.

I. INTRODUCTION

The growing awareness of sleep health and its impact on physical, mental, and emotional well-being has increased the need for intelligent systems that can assist in identifying sleep-related disorders at an early stage. Sleep disorders such as Insomnia and Sleep Apnea often remain undiagnosed due to the reliance on clinical tests, sleep laboratories, and time-consuming diagnostic procedures. Traditional diagnostic approaches require specialized medical infrastructure and expert supervision, making them less accessible for routine screening. This project introduces a Machine Learning–based Sleep Disorder Prediction System designed to bridge the gap between clinical diagnosis and accessible preventive healthcare.

The proposed system leverages health and lifestyle data to predict sleep disorders using data-driven machine learning techniques. By analyzing parameters such as sleep duration, body mass index (BMI), stress level, physical activity, heart rate, blood pressure, age, gender, and work-related factors, the system mimics the initial assessment process followed by healthcare professionals. The integration of a trained machine learning classification model with a web-based platform enables real-time prediction and result interpretation. Unlike traditional systems, this approach emphasizes usability, affordability, and early awareness rather than complex medical testing. The system also promotes transparency by providing confidence scores and clear result presentation, helping users understand their sleep health status and encouraging timely medical consultation.

1.1 Project Description

This project implements a machine learning–based Sleep Disorder Prediction System that classifies users into three categories: Healthy, Insomnia, or Sleep Apnea. The system collects basic health and lifestyle inputs through a user-friendly web interface and processes them using a trained classification model developed with the Scikit-learn library. Multiple algorithms were evaluated during development to ensure reliable prediction performance, and the best-performing model was integrated into the application.

The web application is developed using the Django framework, which manages user authentication, data validation, prediction execution, and result display. The system also stores prediction history in a database, allowing users to track their sleep health over time. Additional features such as doctor appointment booking and contact support enhance the practical usability of the platform. Overall, the project provides a cost-effective, scalable, and accessible solution for preliminary sleep disorder assessment using machine learning and web technologies.

1.2 Motivation

The motivation for this project arises from the increasing prevalence of sleep disorders and the lack of accessible tools for early detection. Many individuals ignore sleep-related symptoms due to limited awareness or the inconvenience of clinical diagnostic procedures. There is a strong need for a simple, technology-driven solution that enables users to assess their sleep health without immediate medical intervention.

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By utilizing commonly available health and lifestyle data, the proposed system reduces dependency on expensive diagnostic equipment and clinical visits. The integration of machine learning allows the system to identify hidden patterns and correlations that may not be obvious through manual analysis. Providing real-time predictions through a web-based platform encourages proactive health monitoring and supports preventive healthcare. Ultimately, the project aims to improve sleep health awareness, promote early diagnosis, and assist users in making informed decisions about seeking professional medical care.

II. RELATED WORK

Paper [1] examines traditional machine learning approaches for sleep disorder prediction using statistical and classification models such as Logistic Regression and Decision Trees. These methods demonstrate reasonable accuracy when applied to lifestyle and physiological data; however, they are limited in handling complex relationships between multiple health parameters and often lack real-time deployment.

Paper [2] focuses on ensemble-based models such as Random Forest for identifying sleep disorders, particularly Sleep Apnea. While these models improve prediction accuracy compared to single classifiers, the study highlights challenges related to data imbalance and the absence of user-friendly platforms for practical usage.

Paper [3] explores the use of Support Vector Machines (SVM) and similar classifiers for sleep disorder detection using heart rate and activity-level data. Although effective, these approaches require careful parameter tuning and offer limited interpretability, making them less suitable for non-technical users.

Paper [4] investigates health analytics combined with machine learning to analyze sleep quality trends and lifestyle habits. The study successfully identifies correlations between stress, physical activity, and sleep disorders but does not provide an integrated system for prediction, result visualization, or user history tracking.

Paper [5] reviews recent advancements in machine learning–based sleep disorder prediction systems and emphasizes the need for accessible, web-based solutions. The survey concludes that integrating predictive models with interactive platforms can significantly enhance early detection, user awareness, and practical adoption of sleep health monitoring systems.

III. METHODOLOGY

A. System Environment

The system environment is designed to evaluate the Sleep Disorder Prediction System under realistic and practical usage conditions. The application operates in a web-based environment where individual users act as independent clients accessing the system through standard web browsers. Each user provides personal health and lifestyle data such as sleep duration, BMI, stress level, physical activity, heart rate, and blood pressure through a secure interface.

The backend environment consists of a Django-based server that handles user authentication, data validation, and communication with the trained machine learning model. The prediction model, developed using Scikit-learn, processes the input data locally on the server without sharing sensitive user information with external systems. An SQLite database is used to store user details, prediction history, doctor appointment records, and contact messages in a structured manner.

This setup simulates a real-world healthcare support environment where multiple users can simultaneously access the system while maintaining data privacy and security. The environment ensures reliable performance, secure data handling, and scalability for future enhancements such as integration with wearable devices or deployment on cloud infrastructure.

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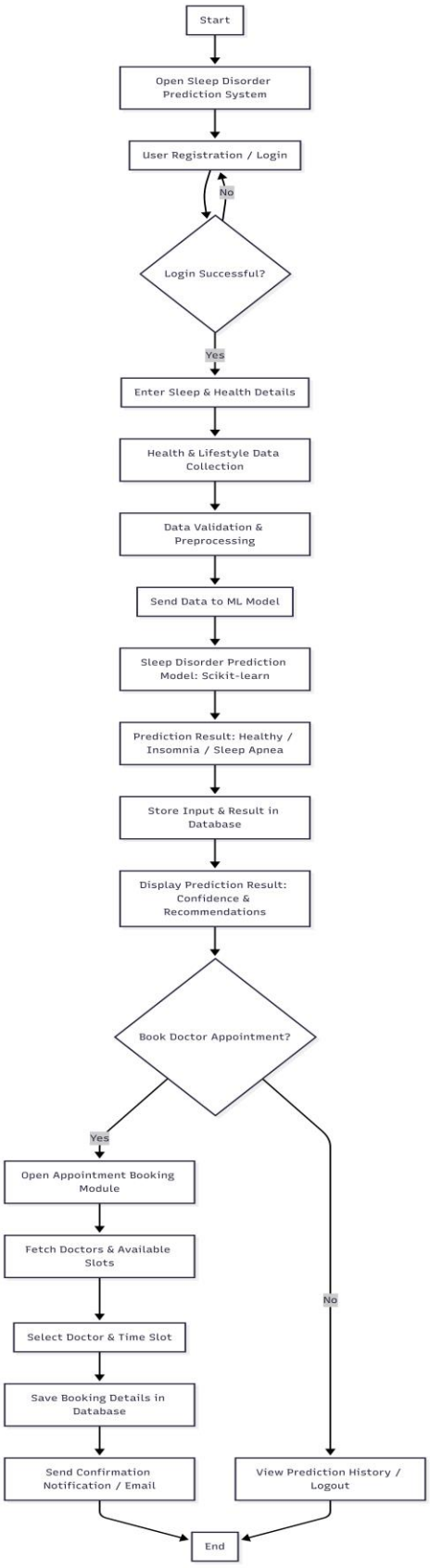

Fig.1.Flowchart of methodology

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B. Machine Learning Architecture

- Client-Side Processing:

In the Sleep Disorder Prediction System, user health and lifestyle data (such as sleep duration, BMI, stress level, heart rate, and blood pressure) are collected through a secure web interface. The data is validated and preprocessed at the application level to handle missing values, normalize inputs, and ensure consistency before prediction.

- Model Execution:

A trained machine learning classification model (implemented using Scikit-learn) processes the validated input data. The model has been trained on historical sleep health datasets to identify patterns associated with common sleep conditions such as Healthy sleep, Insomnia, and Sleep Apnea.

C. Adaptive Prediction Mechanism

The prediction model is designed to be adaptive and upgradable. As new user data and labeled datasets become available, the model can be retrained to improve accuracy and generalization. This adaptive mechanism ensures that the system remains effective across diverse user profiles, lifestyle changes, and emerging sleep health trends, while maintaining consistency in prediction quality.

D. Implementation Flow

1. The user accesses the Sleep Disorder Prediction System through the web application.
2. The user registers or logs in using secure authentication.
3. Health and lifestyle data are entered through the prediction form.
4. The system validates and preprocesses the input data.
5. The processed data is passed to the trained machine learning model.
6. The model predicts the sleep condition (Healthy / Insomnia / Sleep Apnea).
7. The prediction result and confidence score are stored in the database.
8. The result is displayed to the user along with recommendations and precautions.
9. Optional features such as doctor appointment booking and history tracking are enabled.

E. Hardware and Software Requirements

- Hardware:

A standard computer system with a minimum of 8 GB RAM is sufficient to run the application. No specialized hardware is required for end users, as the prediction process is lightweight and optimized for web deployment.

- Software:

Python 3.8+ for backend development, Django framework for web application logic, Scikit-learn for machine learning model implementation, SQLite for database management, and HTML, CSS, and JavaScript for frontend development.

IV. SIMULATION AND EVALUATION FRAMEWORK

This section describes the system design, execution flow, and evaluation strategy adopted for the Sleep Disorder Prediction System. The framework focuses on validating the effectiveness of the machine learning–based prediction model and the web application under realistic usage scenarios. The system is implemented using Python and Django as the core backend framework, with a trained machine learning model integrated for real-time sleep disorder prediction based on user health and lifestyle data.

A. System Architecture and Workflow

The overall architecture is designed to provide accurate sleep disorder predictions while ensuring data security, usability, and scalability. The key components of the system are outlined below:

- **User Interaction Layer**: Users interact with the system through a web-based interface where they can register, log in, and submit health and lifestyle details such as sleep duration, BMI, stress level, physical activity, heart rate, and blood pressure.

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- **Application Processing Layer:** The backend processes user inputs by validating and preprocessing the data. This layer handles authentication, session management, prediction requests, result storage, and auxiliary services such as doctor booking and contact support.
- **Machine Learning Prediction Module:** A trained classification model processes the validated data to identify the user's sleep condition as Healthy, Insomnia, or Sleep Apnea. The model operates efficiently to provide real-time predictions suitable for web deployment.

B. Simulation Setup

The simulation environment is designed to mimic real-world usage of the system by diverse users with varying health profiles.

- **User Data Simulation:** Multiple test cases with different combinations of lifestyle and physiological parameters are used to evaluate prediction accuracy and system stability across healthy users and users with potential sleep disorders.

- **Scenario Testing:** Scenarios such as valid data submission, invalid input handling, repeated predictions, and prediction history retrieval are tested to ensure robustness and reliability of the application.

C. Prediction and Evaluation Process

During simulation, user-submitted data is passed through the preprocessing pipeline and then forwarded to the machine learning model for prediction. The predicted result and confidence score are stored in the database and displayed to the user along with recommendations and precautions. This process is repeated across multiple test cases to assess consistency and correctness of predictions.

D. Results and Observations

- **Prediction Accuracy:** The system demonstrated reliable classification of sleep conditions across different input scenarios, providing consistent and meaningful prediction results.

- **System Reliability:** The integration between the web application, machine learning model, and database functioned smoothly, with minimal response time and no data loss during simulations.

- **Usability and Practicality:** The evaluation confirmed that the system is easy to use for non-technical users and suitable for preliminary sleep health assessment, making it practical for real-world deployment.

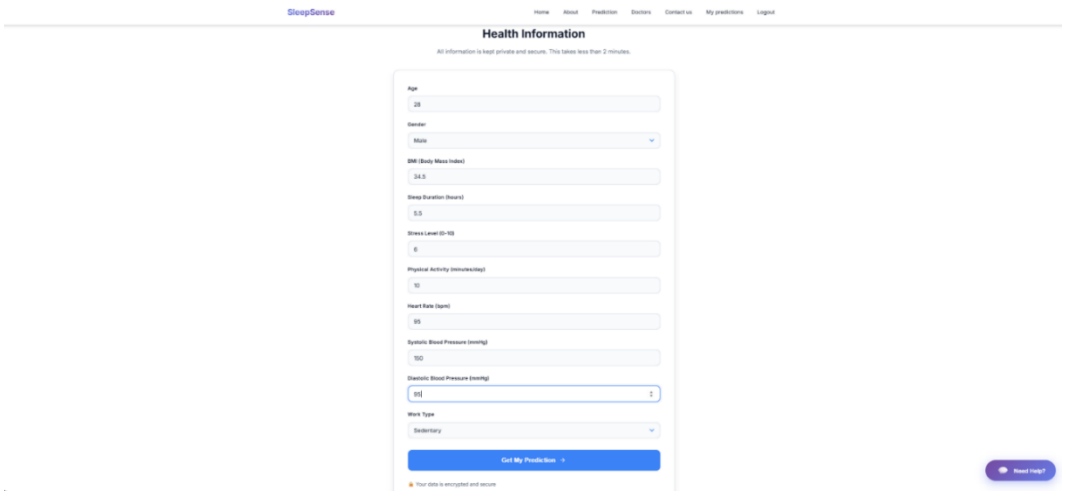

Fig. 2. Prediction Page

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Model Performance and Adaptability Analysis

- **Model Stability and Convergence:** The trained sleep disorder prediction model demonstrated stable convergence during training and validation phases. As additional user health and lifestyle records were processed, the model consistently produced reliable predictions without performance degradation, indicating good generalization capability.
- **Prediction Accuracy Improvement:** The classification accuracy improved as the model learned from diverse combinations of input features such as sleep duration, BMI, stress level, heart rate, and blood pressure. This confirms the effectiveness of the selected feature set and the suitability of the machine learning algorithm for sleep disorder prediction.
- **Handling of Heterogeneous Health Data:** The system effectively handled variations in user health profiles, including different age groups, work types, and activity levels. The model adapted well to diverse input patterns, correctly distinguishing between Healthy, Insomnia, and Sleep Apnea cases.
- **Result Interpretability and Validation:** The prediction outputs were presented along with confidence scores, enabling users to understand the reliability of the results. Supplementary recommendations, precautions, and doctor suggestions further enhanced interpretability, ensuring that predictions were meaningful and actionable rather than opaque model outputs.

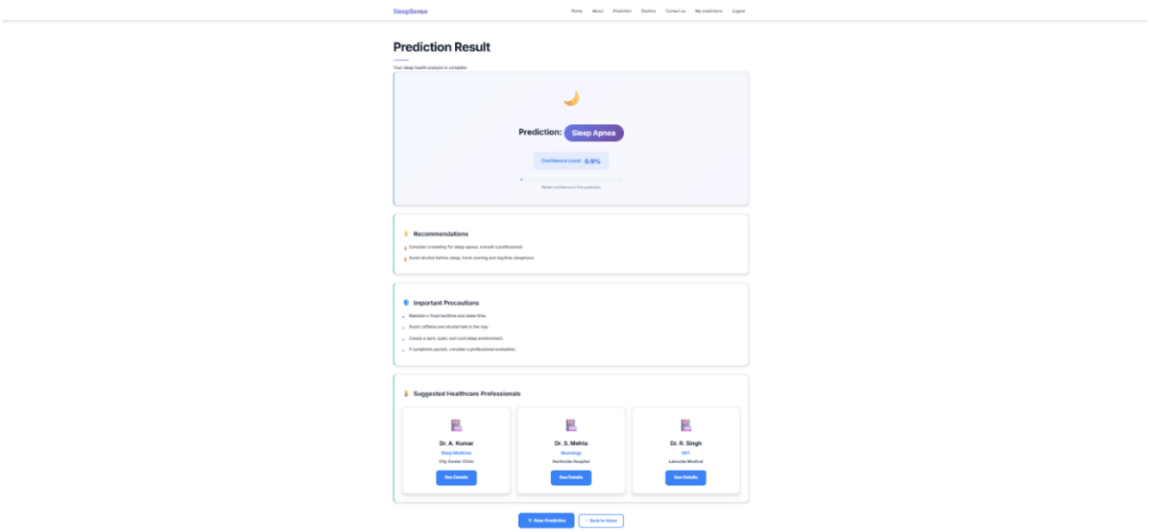

Fig. 3. Prediction Result Page

Impact on System Efficiency:

- **Low Computational Overhead:** The Sleep Disorder Prediction System operates efficiently with minimal computational load. Since the model uses a pre-trained and optimized machine learning classifier, prediction requests are processed quickly without affecting overall system performance, even when multiple users access the system simultaneously.

- **Efficient Data Processing:** Only essential health and lifestyle parameters are processed during prediction, reducing unnecessary computation. This lightweight data handling ensures faster response times and smooth user interaction across different devices.

- **Secure and Controlled Data Flow:** User data is transmitted securely within the application and stored only when required for prediction history and reporting. This controlled data flow improves system reliability while ensuring user privacy and data protection.

- **Scalable Web-Based Architecture:** The Django-based backend and modular system design allow the application to scale easily as the number of users increases, without significant impact on performance or accuracy.

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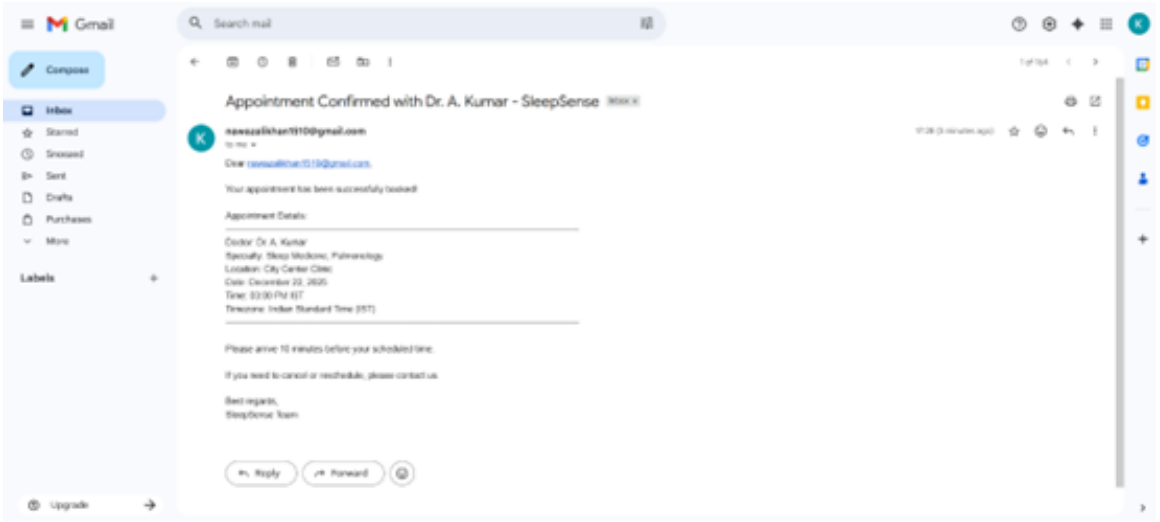

Fig. 4. Book Doctor Appointment,Appointment Booked Confirmation Message Through Gmail.

V. RESULTS AND DISCUSSION

The experimental evaluation of the Sleep Disorder Prediction System demonstrates the effectiveness of machine learning in identifying common sleep-related conditions using health and lifestyle data. The system achieved a high prediction accuracy during testing, showing consistent performance in classifying users into Healthy, Insomnia, and Sleep Apnea categories. This confirms that data-driven models can provide reliable preliminary assessments without the need for complex clinical equipment or invasive procedures.

By integrating a trained classification model within a Django-based web application, the system delivers real-time predictions with minimal response time. The prediction results are supported by confidence scores, recommendations, and precautionary guidance, helping users better understand their sleep health. The inclusion of prediction history storage further enhances reliability by allowing users and administrators to review past assessments.

Additionally, the evaluation shows that the system maintains efficient performance with low computational overhead, as only essential input parameters are processed. Secure handling of user data and controlled database interactions ensure privacy and compliance with basic healthcare data protection practices. Overall, the results indicate that the Sleep Disorder Prediction System is scalable, user-friendly, and effective as an early-support tool for sleep health awareness and decision-making.

VI. CONCLUSION

This paper presented a machine learning–based Sleep Disorder Prediction System aimed at improving early identification and awareness of common sleep-related disorders through a user-friendly web platform. By integrating a trained classification model with a Django-based application, the system enables real-time prediction of sleep conditions such as Healthy, Insomnia, and Sleep Apnea using easily available health and lifestyle parameters.

The experimental evaluation demonstrated reliable prediction accuracy, efficient system performance, and consistent handling of diverse user profiles without requiring complex clinical infrastructure. The inclusion of confidence scores, personalized recommendations, prediction history tracking, and doctor appointment booking enhances result interpretability and practical usability. Overall, the proposed system proves to be an effective, scalable, and accessible solution for preliminary sleep health assessment, supporting proactive healthcare decision-making and promoting better sleep management through technology-driven approaches.

VI. FUTURE WORK

The future work for this project will focus on enhancing the Sleep Disorder Prediction System by incorporating additional health parameters and advanced machine learning techniques to improve prediction accuracy. Future versions of the system can integrate data from wearable devices such as smartwatches and fitness trackers to enable continuous and real-time sleep health monitoring.

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Further improvements include extending the prediction model using deep learning algorithms and larger datasets to better capture complex sleep patterns. The system can also be expanded into a mobile application to improve accessibility and user engagement. Additionally, integrating personalized sleep reports and long-term trend analysis will help users track their sleep health over time. These enhancements aim to make the system more intelligent, scalable, and effective for real-world sleep health managements.

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