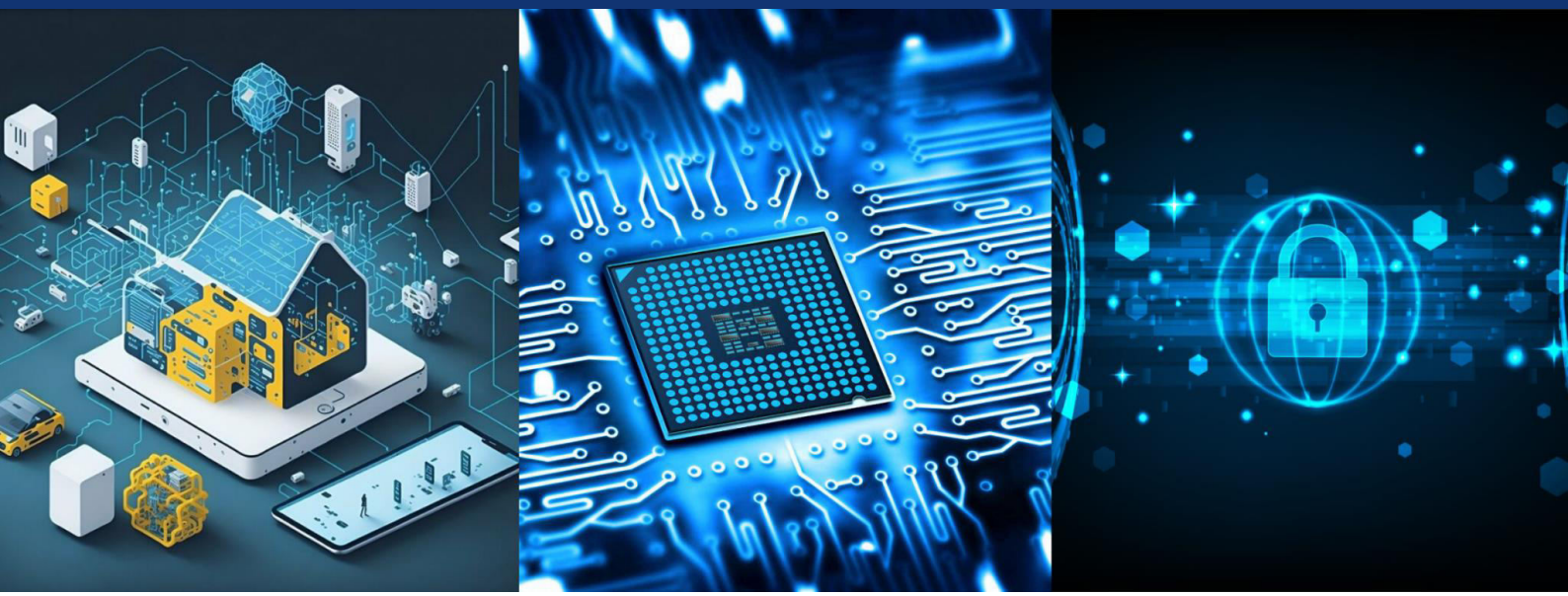
IJIRCCE

ISSN(O): 2320-9801

ISSN(P): 2320-9798



International Journal of Innovative Research in Computer and Communication Engineering

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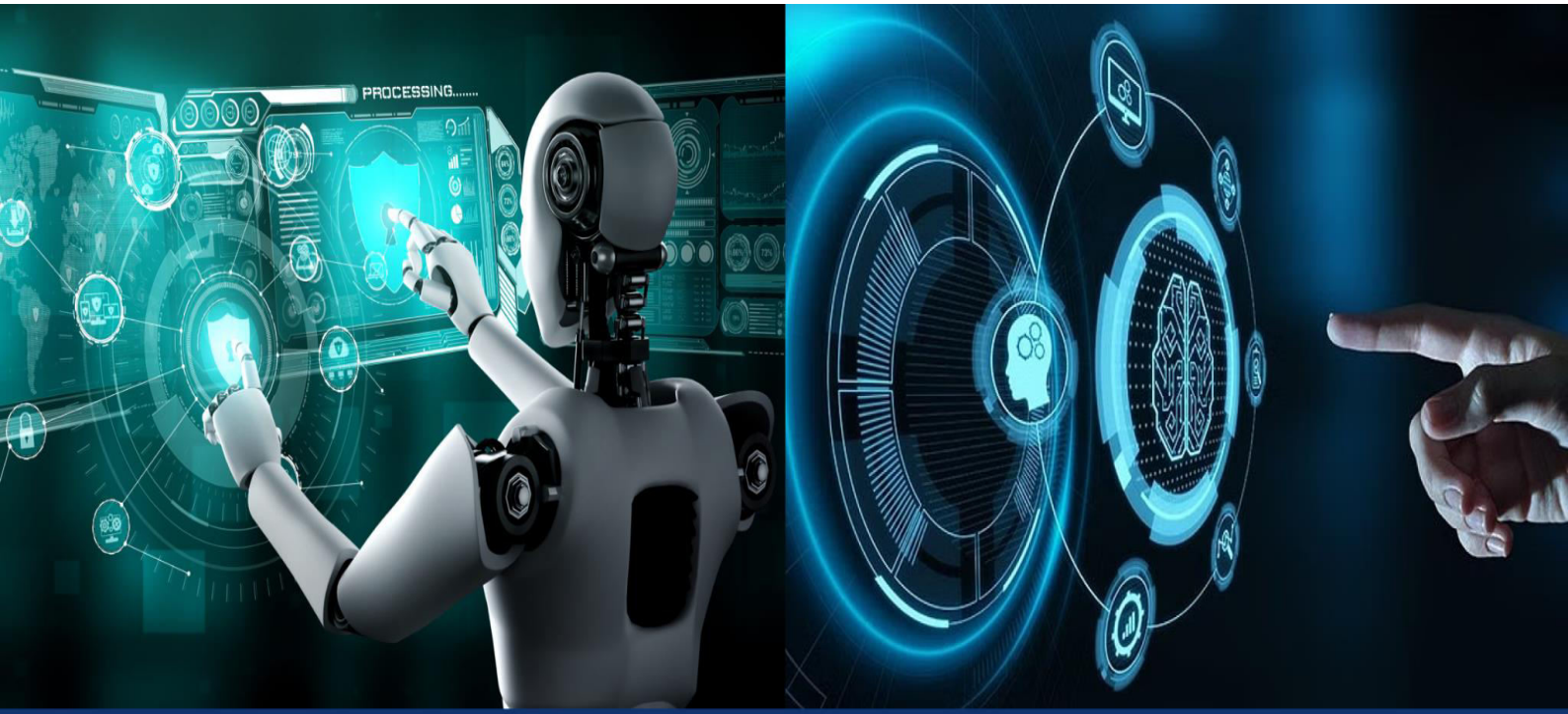

Impact Factor: 9.927

Volume 14, Issue 6, June 2026

© 2026 IJIRCCE | Volume 14, Issue 6, June 2026 DOI: 10.15680/IJIRCCE.2026.1406062

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 9.927| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Neurodream Analytics: A Smart AI Framework for Sleep Disorder Identification

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ABSTRACT: Sleep disorders are among the most common health issues affecting millions of people worldwide [1][2], leading to reduced productivity, poor mental health, and various chronic medical conditions. Early detection of these disorders is essential for effective treatment and improved quality of life. Traditional diagnostic methods are often expensive, time-consuming, and require specialized clinical facilities. To address these limitations, this paper presents Neurodream Analytics, an intelligent AI-based framework for sleep disorder identification. The proposed system utilizes machine learning techniques to analyze sleep-related parameters such as sleep duration, heart rate, stress level, and physical activity patterns. The collected data undergoes preprocessing and feature extraction to improve prediction accuracy. Multiple classification algorithms are employed to identify sleep disorders including insomnia, sleep apnea, and narcolepsy. The framework provides automated analysis and reliable predictions, reducing dependence on manual diagnosis. Experimental evaluation demonstrates the effectiveness of the proposed approach in detecting sleep abnormalities with high accuracy.

KEYWORDS: Sleep Disorder Detection, Artificial Intelligence, Machine Learning, Healthcare Analytics, Sleep Monitoring, Predictive Modeling, Insomnia, Sleep Apnea, Narcolepsy.

I. INTORDUCTION

Sleep is an essential biological process that supports physical health, mental well-being, and daily performance. However, sleep disorders such as insomnia, sleep apnea, and narcolepsy affect millions of people worldwide, leading to reduced productivity and various health complications.

Traditional diagnostic techniques like polysomnography (PSG) provide accurate results but require specialized equipment, clinical supervision, and significant time. Due to these limitations, many sleep disorders remain undiagnosed during their early stages.

Recent developments in Artificial Intelligence (AI) and Machine Learning (ML) [3][16][17] have enabled the development of intelligent healthcare systems capable of analyzing sleep-related data efficiently. These technologies can identify hidden patterns and support early detection of sleep abnormalities.

This paper proposes Neurodream Analytics, an AI-based framework that analyzes sleep parameters and predicts sleep disorders using machine learning algorithms. The system aims to provide accurate, fast, and user-friendly sleep disorder identification for improved healthcare support.

II. LITERATURE REVIEW

Several studies have explored the use of Artificial Intelligence and Machine Learning techniques for sleep disorder detection. Traditional diagnostic methods such as polysomnography provide accurate results but are expensive and require clinical supervision [39][40].

Researchers have applied machine learning algorithms including Support Vector Machine (SVM), Decision Tree, and Random Forest [25][26][27] to analyze sleep-related data and classify sleep disorders. These approaches have shown promising results in improving prediction accuracy and reducing diagnosis time.

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Recent advancements in deep learning models such as Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) networks [21][23][24] have further enhanced sleep pattern analysis. These models can automatically identify complex relationships within physiological data and support early diagnosis.

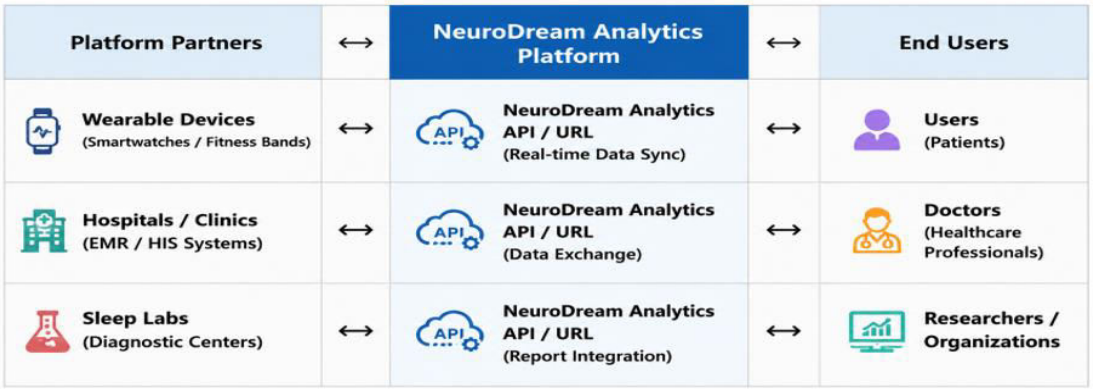
Based on the findings of previous studies, Neurodream Analytics utilizes AI-based techniques to provide an efficient, accurate, and user-friendly framework for sleep disorder identification and monitoring.

III. SYSTEM OVERVIEW

Neurodream Analytics is an AI-driven healthcare system developed to identify sleep disorders using machine learning techniques. The system analyzes sleep-related parameters such as sleep duration, heart rate, stress level, and activity patterns to detect abnormalities in sleeping behavior.

The framework consists of four major stages: data collection, data preprocessing, model training, and prediction. After processing the input data, machine learning algorithms classify the user's condition into categories such as Insomnia, Sleep Apnea, Narcolepsy, or Normal Sleep.

The system is designed to provide accurate, fast, and user-friendly predictions, enabling early detection of sleep disorders and supporting better health monitoring.



NeuroDream Analytics – Platform Integration Architecture

IV. METHODOLOGY

The development of Neurodream Analytics follows a structured approach to ensure accurate sleep disorder identification. The methodology consists of the following phases.

4.1 Data Collection

Sleep-related parameters such as sleep duration, heart rate, stress level, and physical activity are collected from the dataset for analysis.

4.2 Data Preprocessing

The collected data is cleaned by handling missing values, removing inconsistencies, and normalizing features [13][15] to improve data quality and model performance.

4.3 Feature Extraction

Important attributes influencing sleep disorders are identified and selected to enhance the efficiency and accuracy of the prediction model.

4.4 Model Training

Machine learning algorithms such as KNN, SVM, Random Forest, Decision Tree, and Neural Networks are trained [25][26][27][28][36] using the processed dataset to learn sleep-related patterns.

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4.5 Prediction and Classification

The trained model analyzes user input data and classifies the sleep condition into categories such as Insomnia, Sleep Apnea, Narcolepsy, or Normal Sleep.

4.6 Performance Evaluation

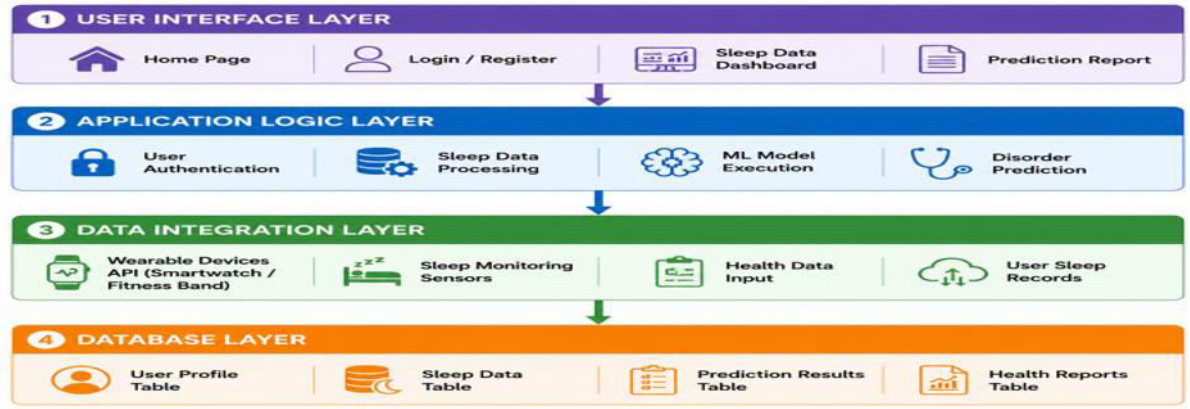
The system performance is evaluated using metrics such as Accuracy, Precision, Recall, and F1-Score to determine the effectiveness of the proposed framework.

V. SYSTEM ARCHIETCTURE

The architecture of Neurodream Analytics follows a layered design that enables efficient processing and classification of sleep-related data.

The system consists of six major layers: User Input Layer, Data Preprocessing Layer, Feature Extraction Layer, Machine Learning Layer, Prediction and Analysis Layer, and Reporting Layer.

The User Input Layer collects sleep-related parameters from users. The Data Preprocessing Layer improves data quality through cleaning and normalization techniques. The Feature Extraction Layer identifies the most relevant attributes affecting sleep disorders. The Machine Learning Layer applies classification algorithms to learn sleep patterns and predict disorders. The Prediction and Analysis Layer generates diagnostic results along with confidence scores. Finally, the Reporting Layer presents the prediction results and health insights in a user-friendly format.



NeuroDream Analytics – Layered System Architecture for Sleep Disorder Detection

VI. MODULES

User Module: In this module

- User can register and login into the system
- User can enter personal and health related data
- User can view prediction results
- User receives suggestions for improving sleep health

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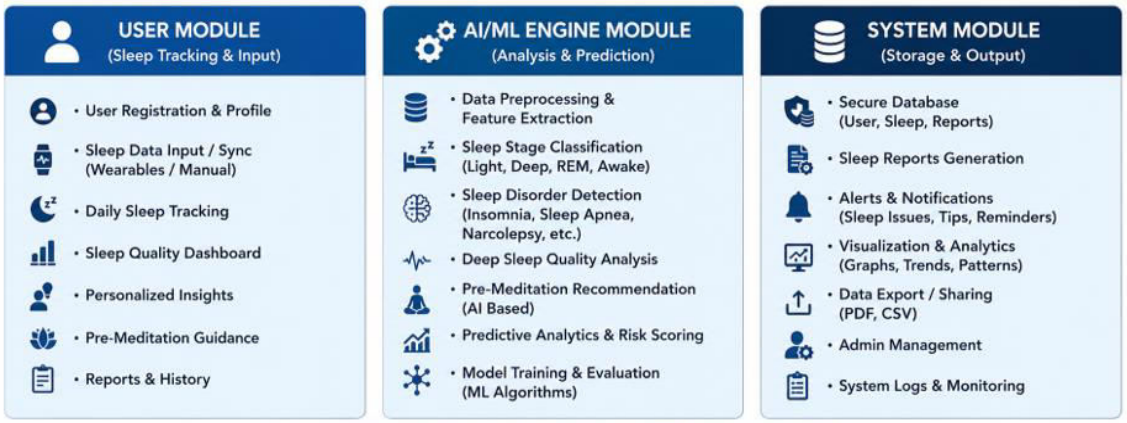

NeuroDream Analytics – Sleep Disorder Detection System Architecture
with Deep Sleep Analysis & AI-Powered Pre-Meditation Prediction

Feature Selection Module: In this module:
- Data Collection from user health records
- Feature Extraction & Processing (age, stress, sleep duration)
- Selection of important features affecting sleep disorders

VII. IMPLEMENTATION DETAILS

7.1 Technology Stack
The proposed system is developed using Python as the programming language and Django as the web framework. Machine learning models are implemented using Scikit-learn [14], while data processing is performed using NumPy and Pandas [15]. SQLite is used for database management.

7.2 Frontend Implementation
The user interface is designed to provide a simple and interactive environment where users can enter sleep-related parameters and view prediction results easily.

7.3 Backend Implementation
The backend manages data processing, model execution, prediction generation, and communication between the user interface and database.

7.4 Database Design
The database stores user information, sleep-related data, prediction results, and generated reports.
SQLite is used to ensure efficient data storage and retrieval.

7.5 Model Implementation
Machine learning algorithms such as KNN, SVM, Decision Tree, Random Forest, and Neural Networks are trained using the processed dataset. The best-performing model is selected for sleep disorder prediction.

7.6 Security Measures
Input validation, secure data handling, and controlled database access mechanisms are implemented to ensure data integrity and system reliability.

VIII. EXPERIMENTAL DETAILS AND RESULTS

8.1 Experimental Setup
The proposed system was implemented and tested using Python, Django, Scikit-learn, NumPy, and Pandas. The experiments were conducted on a system with Intel Core i5 processor, 8GB RAM, and Windows operating system. Sleep-

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related parameters such as sleep duration, heart rate, stress level, and activity patterns were used for model training and evaluation.

8.2 Test Results

Several machine learning models were evaluated for sleep disorder prediction. The performance of the models was measured using standard classification metrics.

Test Case	Description	Result	Status
User Authentication	Login / Registration with valid and invalid credentials	Passed	✓
Sleep Data Input	Enter sleep parameters like duration, heart rate, stress level	Passed	✓
Data Preprocessing	Cleaning, normalization and feature processing	Passed	✓
ML Model Execution	Training and testing machine learning models	Passed	✓
Sleep Disorder Prediction	Classifying Insomnia, Sleep Apnea, Narcolepsy, Normal Sleep	Passed	✓
Report Generation	Generate prediction results and health insights	Passed	✓
Database Management	Store user details, sleep records and prediction history	Passed	✓
Response Time	Prediction generated within acceptable time	Passed	✓
Dashboard Visualization	Display sleep analysis graphs and results	Partial	~
Mobile Responsiveness	System display on multiple devices	Partial	~

Test Case Results for NeuroDream Analytics – Sleep Disorder Detection System

8.3 Performance Evaluation

The system performance was evaluated using Accuracy, Precision, Recall, and F1-Score metrics. Experimental results indicate that the proposed framework effectively identifies sleep disorders with high reliability and minimal prediction delay.

8.4 Observations

The proposed system successfully classified sleep disorders such as Insomnia, Sleep Apnea, and Narcolepsy. The use of machine learning algorithms improved prediction accuracy and reduced the complexity associated with traditional diagnostic procedures.

IX. APPLICATIONS

- **Healthcare Monitoring:**

The system helps healthcare professionals monitor sleep patterns and identify possible sleep disorders at an early stage.

- **Early Diagnosis and Prevention:**

AI-based prediction helps in detecting disorders such as insomnia, sleep apnea, and narcolepsy before they become severe.

- **Personal Sleep Tracking:**

Users can monitor their sleep quality, duration, and sleeping behavior through intelligent analysis.

- **Wearable Device Integration:**

The system can be integrated with smartwatches and fitness devices for real-time sleep data collection.

- **Remote Healthcare Support:**

It enables remote monitoring of patients and supports telemedicine applications.

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• **Research and Clinical Analysis:**
Collected sleep data can assist researchers in studying sleep patterns and improving treatment methods.
• **Personalized Health Recommendations:**
The system can provide customized suggestions based on individual sleep conditions and prediction results.

X. LIMITATIONS

• **Data Dependency:**
The accuracy of the system depends on the quality, quantity, and reliability of the collected sleep data.
• **Limited Dataset Availability:**
Insufficient or imbalanced datasets may affect the performance and generalization ability of machine learning models.
• **Sensor Accuracy:**
Wearable devices and sensors may produce inaccurate readings due to device limitations or improper usage.
• **Individual Sleep Variations:**
Different individuals have different sleep patterns, which can make accurate classification challenging.
• **Need for Continuous Monitoring:**
Effective prediction requires regular sleep data collection over a period of time.
• **Clinical Validation Requirement:**
AI-based predictions should be further validated by medical professionals before making final clinical decisions.
• **Privacy and Security Concerns:**
Sleep and health-related data require secure storage and protection from unauthorized access.

XI. FUTURE ENHANCEMENT

The future scope of NeuroDream Analytics focuses on improving the accuracy, reliability, and usability of the sleep disorder detection system. Advanced deep learning techniques such as CNN, LSTM, and transformer-based models [21][24] can be integrated to enhance prediction performance. The system can be further developed with real-time monitoring capabilities by connecting wearable devices and IoT-based sleep tracking sensors. Using larger and more diverse clinical datasets can improve the generalization of the model. Future enhancements may also include personalized sleep recommendations, mobile application support, and integration with healthcare platforms to assist doctors in better patient monitoring. Additionally, advanced security mechanisms can be implemented to ensure privacy and safe handling of user health data.

XII. CONCLUSION

The proposed NeuroDream Analytics framework provides an effective AI-based approach for identifying sleep disorders using machine learning techniques. The system analyzes sleep-related parameters and applies data preprocessing, feature extraction, and classification methods to detect conditions such as insomnia, sleep apnea, and narcolepsy. Compared with traditional diagnostic approaches, the proposed system offers a faster, cost-effective, and user-friendly solution for sleep health monitoring. The experimental results demonstrate that machine learning models can successfully identify sleep patterns and support early detection of sleep abnormalities. The framework can assist healthcare professionals and individuals in better understanding sleep conditions and improving overall health management. With further improvements in real-time monitoring, advanced AI models, and healthcare integration, NeuroDream Analytics can become a reliable tool for future intelligent sleep analysis systems.

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