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Multi-Algorithm Sleep Disorder Classification Using Genetic Algorithm Optimization

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ABSTRACT

Sleep disorder classification is crucial in improving human quality of life. Sleep disorders and apnea can have a significant influence on human health. Sleep-stage classification by experts in the field is an arduous task and is prone to human error. The development of accurate machine learning algorithms (MLAs) for sleep disorder classification requires analysing, monitoring and diagnosing sleep disorders. This paper compares deep learning algorithms and conventional MLAs to classify sleep disorders. This study proposes an optimised method for the Classification of Sleep Disorders and uses the Sleep Health and Lifestyle Dataset publicly available online to evaluate the proposed model. The optimisations were conducted using a genetic algorithm to tune the parameters of different machine learning algorithms. An evaluation and comparison of the proposed algorithm against state-of-the-art machine learning algorithms to classify sleep disorders. The dataset includes 400 rows and 13 columns with various features representing sleep and daily activities. The k-nearest neighbours, support vector machine, decision tree, random forest and artificial neural network (ANN) deep learning algorithms were assessed. The experimental results reveal significant performance differences between the evaluated algorithms. The proposed algorithms obtained a classification accuracy of 83.19%, 92.04%, 88.50%, 91.15% and 92.92%, respectively. The ANN achieved the highest classification accuracy of 92.92%, and its precision, recall and F1-score values on the testing data were 92.01%, 93.80% and 91.93%, respectively. The ANN algorithm that achieved high accuracy than other tested algorithms.

INTRODUCTION:

Sleep is a vital physiological function necessary for physical and mental health. Sleep helps strengthen the body and consolidate the brain and memories. Sleep quality affects cognitive functions, particularly in children and older drivers at increased risk of accidents. Sleep deprivation can affect the human body and cause health problems like heart disease, diabetes and obesity. Physicians, doctors, medical professionals and experts must manually evaluate polysomnography (PSG) records, which can lead to different assessments of sleep stages. Manual classification is prone to human error and is time-consuming for sleep-stage classification. Philips conducts an annual World Sleep Day survey on sleep-related attitudes and behaviours. In 2021, the survey polled more than 13,000 adults in 13 countries. Only 55% of adults were satisfied with their sleep, and the rest were dissatisfied with their sleep quality. They suffered from sleep quality because of such factors as the coronavirus disease 2019 (COVID-19)

pandemic, sleep apnoea and insomnia. The statistics revealed that 37% said the pandemic negatively influenced their ability to sleep well. Moreover, 37% of participants reported suffering insomnia, while 29% snore, 22% have a shift-work sleep disorder, and 12% experience sleep apnoea. Medical professionals and sleep experts evaluate the quality of sleep by analysing the sleep system classified for various sleep stages. There are five stages of sleep: wakefulness, N1, N2, N3, and rapid-eye movement (REM). Wakefulness is the stage of alertness when individuals are aware of their surroundings. Brain waves are fast and irregular during consciousness. In N1, the lightest stage of sleep, brain waves are slow, and the muscles relax.

LITERATURE SURVEY

Classification of Sleep Disorders Using Random Forest on SleepHealth and Lifestyle Dataset: https://journal.ittelkom-pwt.ac.id/index.php/dinda/article/download/1215/356 Authors: A. Hidayat and J. Dinda Year: Aug, 2023, Data Sci., Inf. Technol., Data Anal., vol. 3, no. 2, pp. 71–76

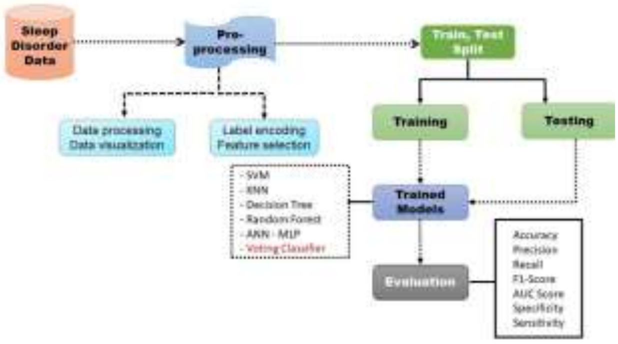
ABSTRACT: This study aims to classify sleep disorders using the Random Forest method on the Sleep Health and Lifestyle dataset. This dataset contains information about sleep, lifestyle, and relevant health factors. In this study, the dataset was processed and divided into training and testing subsets. The Random Forest model was trained using the training subset with sleep and health related features. The quality of the split in each decision tree was measured using the Gini Index. The model was evaluated using the testing subset to measure its accuracy and classification performance. The evaluation results showed that the Random Forest model was able to predict sleep disorders with good accuracy. Analysis of class distributions, correlation relationships between features, and visualization by gender provided insights into the factors that influence sleep disorders. This research has thepotential to contribute to the field of health and medicine, especially in the recognition and diagnosis of sleep disorders. Merits: • Effective Use of Random Forest: The model achieved good accuracy in classifying sleep disorders. • Health-Focused Dataset: Uses the Sleep Health and Lifestyle dataset, which is rich in relevant features. • Visual Analysis Provided: Correlation analysis and gender-based visualizations offer deeper understanding. • Potential Medical Application: The findings can aid in the early recognition and diagnosis of sleep disorders. Demerits: • No Comparison with Other Models: Only Random Forest was used; no benchmarking with other algorithms. • Limited Evaluation Metrics: The study mainly reports accuracy without discussing precision, recall, or F1-score. • Dataset Details Missing: Lacks detailed info about dataset size, class distribution, and preprocessing steps. • No Generalization Testing: The model wasn't tested on external datasets, limiting its realworld applicability.

2. Application of various machine learning techniques to predict obstructive sleep apnea syndrome severity: https://www.nature.com/articles/s41598-023-33170- 7 Authors: H. Han and J. Oh Year: April 2023, Scientific Reports

ABSTRACT: As the incidence of obstructive sleep apnea syndrome (OSAS) increases worldwide, the need for a new screening method that can compensate for the shortcomings of the traditional diagnostic method, polysomnography (PSG), is emerging. In this study, data from 4014 patients were used, and both supervised and unsupervised learning methods were used. Clustering was conducted with hierarchical agglomerative clustering, K-means, bisecting Kmeans algorithm, Gaussian mixture model, and feature engineering was carried out using both medically researched methods and machine learning techniques. For classification, we used gradient boost-based models such as XGBoost, LightGBM, CatBoost, and Random Forest to predict the severity of OSAS. The developed model showed high performance with 88%, 88%, and 91% of classification accuracy for three thresholds for the severity of OSAS: ApneaHypopnea Index (AHI) 5, AHI 15, and AHI 30, respectively. The results of this study demonstrate significant evidence of sufficient potential to utilize machine learning in predicting OSAS severity. Merits: • Large Dataset Used: Involves data from 4014 patients, providing strong statistical support. • Multiple Algorithms Applied: Both supervised (XGBoost, LightGBM, CatBoost, Random Forest) and unsupervised (K-Means, GMM, etc.) methods were used. • High Classification Accuracy: Achieved up to 91% accuracy, showing strong model performance. • Comprehensive Feature Engineering: Combined domain knowledge with machine learning techniques for feature selection. Demerits: • No Real-Time Validation: The model wasn't validated in a clinical or real-time environment. • Interpretability Not Discussed: The complexity of ensemble models may reduce transparency in medical decision-making. • No Cross-Dataset Testing: Results are based on a single dataset; generalizability is uncertain. • Limited Focus on Class Imbalance: Doesn't mention handling of class imbalance, which can affect severity predictions.

Sleep is a vital physiological function necessary for physical and mental health. Sleep helps strengthen the body and consolidate the brain and memories. Sleep quality affects cognitive functions, particularly in children and older drivers at increased risk of accidents. Sleep deprivation can affect the human body and cause health problems like heart disease, diabetes and obesity. Physicians, doctors, medical professionals and experts must manually evaluate polysomnography (PSG) records, which can lead to different assessments of sleep stages. Manual classification is prone to human error and is time-consuming for sleep-stage classification. Philips conducts an annual World Sleep Day survey on sleep-related attitudes and behaviours. In 2021, the survey polled more than 13,000 adults in 13 countries. Only 55% of adults were satisfied with their sleep, and the rest were dissatisfied with their sleep quality. They suffered from sleep quality because of such factors as the coronavirus disease 2019 (COVID-19) pandemic, sleep apnoea and insomnia. The statistics revealed that 37% said the pandemic negatively influenced their ability to sleep well. Moreover, 37% of participants reported suffering insomnia, while 29% snore, 22% have a shift-work sleep disorder, and 12% experience sleep apnoea. Medical professionals and sleep experts evaluate the quality of sleep by analysing the sleep system classified for various sleep stages. There are five stages of sleep: wakefulness, N1, N2, N3, and rapid-eye movement (REM). Wakefulness is the stage of alertness when individuals are aware of their surroundings. Brain waves are fast and irregular during consciousness. In N1, the lightest stage of sleep, brain waves are slow, and the muscles relax.

System Architecture:



Data Loading Module This module is responsible for importing the Sleep Disorder dataset into the system for further analysis and processing. It initiates the pipeline by reading and validating the dataset structure. 2. Data Preprocessing Module Ensures data quality and readiness for modeling by performing operations like removing duplicates, handling missing values, and dropping irrelevant fields. This step guarantees that the dataset is clean and suitable for machine learning algorithms. 3. Data Visualization Module Implements various plots and charts to provide insights into the dataset. Visualization helps in understanding patterns, trends, and relationships between different features (e.g., sleep disorder vs. age, gender, blood pressure, etc.). 4. Label Encoding Module Converts categorical data into numeric form so that it can be fed into machine learning models. Label encoding maintains the ordinal relationship among values when applicable. 5. Feature Selection Module Identifies the most relevant input features (X) and corresponding target labels (y) for model training, enhancing model efficiency and accuracy by eliminating irrelevant data. 6. Data Splitting Module Splits the preprocessed data into training and testing sets to evaluate the performance of various models. This ensures the generalizability and robustness of the classifiers. 7. Model Generation Module Trains and builds multiple models including: o Support Vector Machine (SVM) o K-Nearest Neighbours (KNN) o Decision Tree (DT) o Random Forest (RF) o Artificial Neural Network (ANN) o Voting Classifier (Ensemble of DT and Bagging with RF) These models are optimized using a Genetic Algorithm to enhance their performance. 8. User Signup and Login Module Facilitates user authentication, ensuring secure access to the application. It includes registration and login functionalities for users. 9. User Input Module Collects new data inputs from users via a web interface for real-time prediction and classification of sleep disorders. 10. Prediction Module Processes the user inputs through the trained model to generate and display final classification results (e.g., No Disorder, Insomnia, Sleep Apnea). 11. Extension Module Incorporates enhancements such as ensemble learning and a Flask-based web application for improved usability. It emphasizes system security, model performance, and interactive user experience.

RESULTS:

Steps: 1. Open the Application: Launch the Pdoctor application in your browser to access the homepage with navigation and a welcome message.

2. Register as a New User: Click the "Register" button, fill in your details like username, email, and password, then click register.

3. Login to the Dashboard: If already registered, enter your username and password on the login page and click the "Login" button.

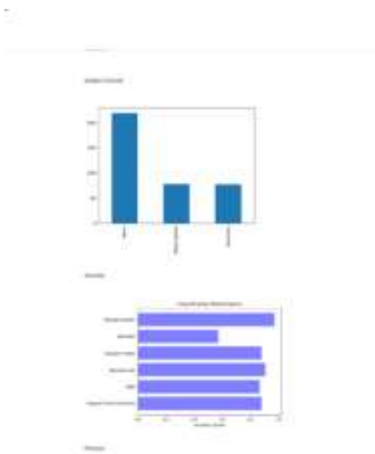
4. Fill the Prediction Form: Enter patient information such as gender, age, occupation, sleep duration, and activity

level in the form.

5. Submit the Form: After filling out the fields, submit the form to get a sleep disorder prediction based on the input.

6. View the Prediction Result: The system displays the outcome—whether the patient suffers from a sleep disorder like insomnia or not.

7. Analyze Graphs and Metrics: Navigate to the Graph section to view model performance charts such as accuracy and classification outcomes.



8. Logout: Click the "Logout" button in the top right to securely end the session and exit the application.

CONCLUSION AND FUTURE ENHANCEMENT In conclusion, the study effectively demonstrates the potential of machine learning and deep learning techniques in accurately classifying sleep disorders, a critical aspect of enhancing patient health outcomes. By leveraging the Sleep Disorder Data Dataset, various algorithms, including KNN, SVM, DT, RF, and ANN, were meticulously evaluated, revealing the strengths and limitations of each approach. The use of a genetic algorithm for optimizing model parameters significantly improved the performance, achieving a notable accuracy of 90.7% with the decision tree model. The implementation of ensemble methods, specifically the Voting Classifier, showcased even greater accuracy, reaching 97.3%, underscoring the efficacy of combining multiple algorithms for improved predictive power. This research not only highlights the advancements in sleep disorder classification but also emphasizes the importance of integrating user-friendly interfaces, such as the proposed web-based platform using Flask, to facilitate accessibility and usability for healthcare professionals. Ultimately, the findings of this study pave the way for further exploration into automated sleep disorder classification systems, promising enhanced diagnostic capabilities that can significantly contribute to better patient care and improved quality of life. Future Scope: The future scope of this research includes the exploration of additional advanced machine learning techniques, such as deep learning architectures like Convolutional Neural Networks (CNNs) and recurrent networks for improved accuracy in sleep disorder classification. Integrating real-time data from wearable devices could enhance the system's predictive capabilities. Furthermore, expanding the dataset to include diverse populations and sleep disorders will improve model generalization.

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