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DEEP LEARNING ENHANCED LIFESTYLE DISEASE PREDICTION AND PERSONALIZED RECOMMENDATION USING ADAM OPTIMIZER

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Abstract—**Sleep problems are getting worse because of the way we live today. We have a lot of stress we do not sleep at times and we do not exercise enough. Sleep disorders like insomnia and sleep apnea can really affect our health, our mental health and how well we can do our daily work. We need to find out if we have these problems early so we can stop them from getting worse.**
This study is about a website that uses a kind of computer program called a Feed forward Neural Network to predict if we have sleep disorders. The website looks at things like how old we're if we are a man or a woman how long we sleep how stressed we are our body mass index, our heart rate and how much we exercise. We chose these things because they are important for our sleep health and we can find out about them without needing to do medical tests.
We make sure the information we use is ready for the computer program by doing some preparation work. Then we use the Feed forward Neural Network to put people into three groups: people with insomnia people with sleep apnea and people with no sleep problems. The computer program is good at finding connections between our lifestyle and our sleep problems, which makes it better at predicting what is going on.
We made a website using Flask that lets people put in their information and get answers away. The website also tells people how likely they are to have sleep problems and gives them advice. The results show that our computer program is good at predicting sleep disorders and can help doctors find problems early. The website can be a tool for people who want to check if they have sleep disorders, like insomnia and sleep apnea.

Index Terms—**Sleep Disorder Prediction, Machine Learning, Random Forest, K-Means Clustering, Healthcare AI, Flask Web Application.**

I. INTRODUCTION

Sleep is really important for our bodies and minds. We need sleep to feel good and be healthy. When we sleep our bodies get to rest. Fix any problems. Sleep also helps us remember things and stay at a weight. A lot of people are not sleeping well these days. This is because we are stressed, we do not exercise we look at screens much and we do not go to bed at the same time every night.

There are sleep problems but insomnia and sleep apnea are the most common sleep problems. Insomnia means we have trouble sleeping or staying asleep so we feel tired. Cannot do things well. Sleep apnea is a problem where we stop breathing when we sleep and this can hurt our hearts and brains. If we do not get help for these sleep problems they can make our lives very hard.

Usually doctors use tests to see if we have sleep problems but these tests are expensive and take a long time. So a lot of people do not get help. We need a way to find out if we have sleep problems that's easy and fast.

Now computers are getting smarter. Can help us with our health. One way computers can help is by using something called Feed forward Neural Networks. These networks are good at looking at information and finding patterns. They can help us understand if we have sleep problems.

We made a system that uses this network to help people with sleep problems. The system asks people about their lives and bodies. Then it tells them if they might have a sleep problem. It also gives them advice, on how to sleep

The main goals of this system are:

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- To make a system that can predict sleep problems
- To make a website that's easy to use and can tell people if they have sleep problems right away
- To help people find out if they have sleep problems early so they can get help

This system wants to help people get sleep without having to go to the doctor all the time. It is an affordable way to find out if we have sleep problems.

II. LITERATURE REVIEW

The use of machine learning and deep learning in healthcare has become really popular lately especially when it comes to predicting diseases and diagnosing them early. Many studies have looked into using computer models to analyze lifestyle data to identify health problems like sleep disorders.

We have been using machine learning methods like Decision Trees, Naive Bayes Support Vector Machines and Logistic Regression for a long time to classify data in healthcare. These models work well with data and give us results that are easy to understand. However they do not work well when the relationships between the input data are complex and not straightforward, which is often the case with real healthcare data.

To fix this problem we started using deep learning techniques. Artificial Neural Networks, Feed forward Neural Net-works have shown great results in classification problems because they can learn to represent data in a hierarchical way. Feed forward Neural Networks have layers of connected neurons and each layer transforms the input data into a higher level of abstraction. This allows the model to find patterns in data related to sleep behavior and lifestyle factors that are not easy to see.

Many research studies have focused on predicting sleep disorders. These studies show that features like sleep duration, stress level, physical activity and body mass index are important for determining sleep quality. Some approaches also use signals like EEG and heart rate but collecting this data requires special equipment and is not always possible for regular people.

Recently we have been trying to use lifestyle data that's easy to get to build systems that can predict sleep disorders. Models based on networks have been more accurate than traditional methods when trained on this kind of data. Also using these models with web or mobile applications makes them easier to use and allows for real-time prediction.

With all these developments many existing systems have problems like not being user-friendly not being accessible to everyone and relying too much on complex medical data. Some models also require a lot of computing power, which makes them less suitable for use on devices.

The system we are proposing tries to solve these problems by using a Feed forward Neural Network trained on lifestyle-based features and making it available through a web application built with Flask. This approach balances prediction accuracy, computing efficiency and user accessibility making it suitable for real-world use. The machine learning and deep learning techniques we are using are really important for making this system work. The Feed forward Neural Network is a part of this system and it is what allows us to make accurate predictions about sleep disorders. By using machine learning and deep learning in this way we can make a difference, in healthcare.

III. METHODOLOGY

The algorithmic model used to predict the existence of sleep disorders uses a sequence of steps that include data preprocessing, feature selection, clustering, probabilistic modeling, and classification. Each of these stages is described in detail based on the actual implementation.

A. System Overview

The system we are talking about is made to figure out sleep problems using a kind of computer program called a Feed forward Neural Network. This program is part of a website that people can use. The system has a steps to follow that changes what the user tells us into something that makes sense.

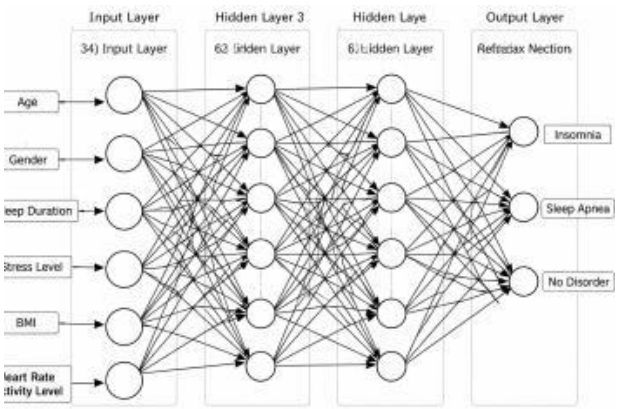

Fig. 1. FNN Architecture

The main steps are:

- User data input through a web interface
- Data preprocessing and transformation
- Prediction using trained FNN model
- Display of results along with risk levels and recommendations

This way of doing things lets us tell people what we think is going on away and it is easy for them to use the system. They do not have to know a lot, about sleep problems or computers to use the sleep disorder system and get help from the sleep disorder system.

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B. Feature Selection

Feature selection plays a critical role in improving model performance and reducing computational complexity. From the available dataset, the most relevant features influencing sleep disorders were selected based on domain knowledge and correlation analysis.

The selected input features are:

- Age
- Gender
- Sleep Duration
- Stress Level
- BMI Category
- Heart Rate
- Physical Activity Level

These features are directly related to lifestyle and physiological conditions that significantly impact sleep health.

C. Data Preprocessing

Before feeding the data into the model, several preprocessing steps are applied to ensure consistency and efficiency:

1. Categorical Encoding: Variables such as Gender, Body Mass Index (BMI) Category, and Physical Activity Level that can be categorized are represented numerically through the use of Label Encoding.
2. Feature Scaling: Numeric features are scaled using the StandardScaler method and normalized such that:

- Mean = 0
- Standard Deviation = 1

It makes sure that all input features will have equal importance in the training process.

3. Target Encoding: The target feature, Sleep Disorder, is encoded into three distinct labels such that:

Class 1 = Insomnia Class 2 = Sleep Apnea Class 3 = No Sleep Disorder

These classes are further encoded as one-hot encoded vectors for multi-class classification purposes via the SoftMax activation function.

D. Feed forward Neural Network (FNN) Architecture

The core of the system is a Feed forward Neural Network, where information flows in a single direction from input to output without feedback loops.

Network Structure:

1. Input Layer:

- Contains 7 neurons corresponding to the selected features

Hidden Layers:

- First Hidden Layer: 64 neurons with ReLU activation
- Second Hidden Layer: 32 neurons with ReLU activation
- Third Hidden Layer: 16 neurons with ReLU activation

Output Layer:

- 3 neurons with SoftMax activation
- Produces probability distribution over three classes

The use of multiple hidden layers allows the model to capture complex nonlinear relationships between input features and sleep disorders.

Features that have high scores have greater influence on sleep disorders.

E. Mathematical Representation

The output of each neuron in the network is computed using the following equation:

$$y = f\left(\sum_{i=1}^{n} w_i x_i + b\right) \quad (1)$$

F. Model Training

The model is trained using supervised learning with labeled data. The training process includes:

- Optimizer: Adam (adaptive learning rate optimization)
- Loss Function: Categorical Cross entropy
- Epochs: 100
- Batch Size: 16
- Train-Test split: 80:20

During training, the model adjusts its weights iteratively to minimize the loss function and improve prediction accuracy.

G. Prediction Process

Once the model is trained, it is used for real-time prediction through the web interface. The prediction process follows these steps:

- Accept user input
- Encode categorical features
- Apply feature scaling using saved scaler
- Pass processed input to the trained FNN model
- Compute probability scores for each class
- Select the class with highest probability
- Display predicted sleep disorder

H. System Integration

The trained FNN model is integrated into a Flask-based web application for real-time usability.

Components:

- Frontend: HTML and CSS (UI)
- Backend: Flask (Python)
- Model: TensorFlow/Keras FNN
- Database: SQLite for storing prediction records The system also includes:
- User input page

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- Result display page with risk visualization

I. Output and Visualization

The system provides comprehensive output to the user, including:

- Predicted sleep disorder
- Risk level (Low, Medium, High)
- Graphical representation
- Personalized health recommendations

This enhances user understanding and encourages preventive actions.

IV. SYSTEM IMPLEMENTATION

The suggested sleep disorders prediction system is realized in the form of a web application combining machine learning techniques at the back end with the graphical interface at the front end. The system is developed using the Flask framework as well as HTML/CSS technologies.

A. System Architecture

The system follows a three-tier architecture:

1. Presentation Layer (Frontend)

- HTML and CSS used to develop
- Gives user interface for data input and results visualization
- Has various pages like login page, prediction page, results page, and admin page

Application layer (Backend)

- Developed by using Flask (web framework of Python)
- Handles routing and data processing along with model incorporation
- Does calculations for predictions and gives output

Data layer

- Includes Dataset and machine and deep learning model
- User predictions can be stored here

B. Backend Implementation (Flask)

The backend handles the processing of user input and prediction generation.

Backend Features:

- Routing (Flask @app.route)
- Handling POST request for form submission
- Data preprocessing
- Model loading/prediction making
- HTML rendering of result

Prediction Process:

$$P(\text{Disorder} \mid \text{Feature}) = \frac{P(\text{Feature} \cap \text{Disorder})}{P(\text{Feature})} \quad (2)$$

- Input from user through form submission
- Validation/transformation of user data
- Feature alignment with model training
- Predictions on sleep disorders
- Display prediction and suggestions

C. Machine Learning and deep learning Integration

The Random Forest algorithm and FNN that was trained is incorporated into the Flask framework. Stages involved:

- Training of model through dataset
- Serialization process for saving the model (for example, pickling)
- Loading of the model within Flask framework

The consistency of training and predictions is guaranteed through feature parity.

D. Visualization Components

The system comprises several visual interfaces:

- Bar Graphs → Highlights important attributes
- Risk Meter → Indicates the severity scale
- Prediction Graph → Presents the probability curve

All these interfaces make the interpretation easier for the user. System Flow Chart

E. System Workflow

The complete workflow is as follows:

- User accesses the web application
- Inputs lifestyle and health data
- Data is sent to Flask backend
- Preprocessing and feature engineering are applied
- Model predicts sleep disorder
- Results and recommendations are displayed

F. Advantages of Implementation

- Real-time prediction system
- User-friendly interface
- Lightweight and efficient
- Scalable for future enhancements
- Easily deployable on web servers

V. RESULTS AND ANALYSIS

This chapter discusses the results obtained by conducting the performance analysis of the developed sleep disorder prediction model, along with the findings obtained from the data set.

A. Experimental Setup

Experimental Framework

The proposed feed forward neural network model was developed and tested using the pre-prepared sleep health and lifestyle dataset. The dataset was split into training and testing sets at a ratio of 80:20 to test the model on unseen datasets.

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The framework for implementation consisted of the following tools:

- Programming Language: Python
- Deep Learning Library: TensorFlow/Keras
- Preprocessing and Evaluation: Scikit-learn

The system was run on a typical computing machine, showing the feasibility of this system without the need for high-end computing resources.

B. Model Performance

Performance of the Model: The model displayed gradual improvements in performance in terms of accuracy alongside a consistent decrease in loss during training epochs. This shows that the model was able to learn from the data with no signs of overfitting.

Observations:
FNN Model is able to differentiate between:

- Insomnia
- Sleep Apnea
- Normal

The model works well with just the lifestyle attributes Predictions are stable across different combinations of inputs

C. Visualization of Results

The system provides multiple visual outputs to enhance user understanding:

1. Risk Level Indicator: A dynamic risk meter visually represents the severity level:

- Low Risk
- Medium Risk
- High Risk

Graphical Representation: A prediction graph is generated to show probability distribution across different classes.
Admin Dashboard: The system stores prediction records and displays them in a tabular format, allowing administrators to:

- Monitor user data
- Analyze trends
- Track system usage

Risk Level Indicator: A dynamic risk meter visually represents the severity level:

- Low Risk
- Medium Risk
- High Risk

Discussion: From the findings obtained from the experiments carried out, the Feed Forward Neural Network (FNN) proves to be very efficient in predicting sleep disorders based on structured lifestyle information. This model differs from other models since it is capable of handling complex relationships among factors like stress, duration of sleep, and body exercise. Furthermore, incorporation of the model in the web appli-cation increases its efficiency since it is easier for users to access and use.

6. Summary: Overall, the results indicate that the proposed system:

- Achieves high prediction accuracy
- Provides fast and reliable outputs
- Is suitable for real-world sleep disorder screening

VI. CONCLUSION AND FUTURE WORK

A. Conclusion

As presented in this paper, an intelligent sleep disorder prediction system with the employment of a Feedforward Neural Network (FNN) has been successfully designed and implemented. The model considers easily obtainable physio-logical and behavioral attributes such as age, gender, hours of sleep, stress score, BMI level, heart rate, and exercise level as inputs and predicts whether the individual is suffering from insomnia, sleep apnea, or is normal.
With the aid of preprocessing methods such as label en-coding and feature scaling, the model successfully classifies data into three different classes: insomnia, sleep apnea, and normal. These results can help identify patients suffering from sleep-related diseases, hence improving their quality of life and reducing associated health risks.
The implementation of the model into the Flask web application helps present a user interface where the users can interact with the system and receive feedback about whether they have a potential risk of suffering from the mentioned diseases. Besides the predictions, the application also performs risk analysis, graphical representation, and provides necessary information and tips.
Based on the experiments performed during the implementation of this project, it was shown that the FNN model provided highly accurate results. This confirms the reliability of the FNN.
Overall, this work bridges the gap between advanced ma-chine learning techniques and real-world healthcare applications by offering a cost-effective, efficient, and scalable solution.

B. Future Work

Though the suggested model operates successfully, there are still some modifications that could help increase the model's efficiency:

1. Utilization of Wearable Devices : New iterations of the software can take into account information from smartwatches and other wearable technologies to track the changes in heart rates, physical activities, and sleeping habits constantly.
2. Implementation of Sophisticated Deep Learning Algorithms: The use of more complicated algorithms like Recur-rent Neural Networks (RNN) and LSTM can help to predict sleep behavior using time-series data.

3. Increase in Dataset Size: With a larger database, containing medical data and other factors related to health, the algorithm will become more efficient.
4. Creation of a Mobile Application: A mobile application will make it much easier for individuals to control their health status and sleep quality from any place at any time.
5. Personalized Recommendation Engine: A sophisticated recommendation engine can be integrated into the system to offer tailored health recommendations depending on the user's past interactions and predictive results.

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