AI-Driven Prediction of Sleep Patterns from Lifestyle Features

This presentation covers analysis of sleep loss effects on reaction time, working memory, and emotional regulation, reducing productivity and increasing safety risks.

We offer personalized sleep recommendations powered by machine learning Algorithms.

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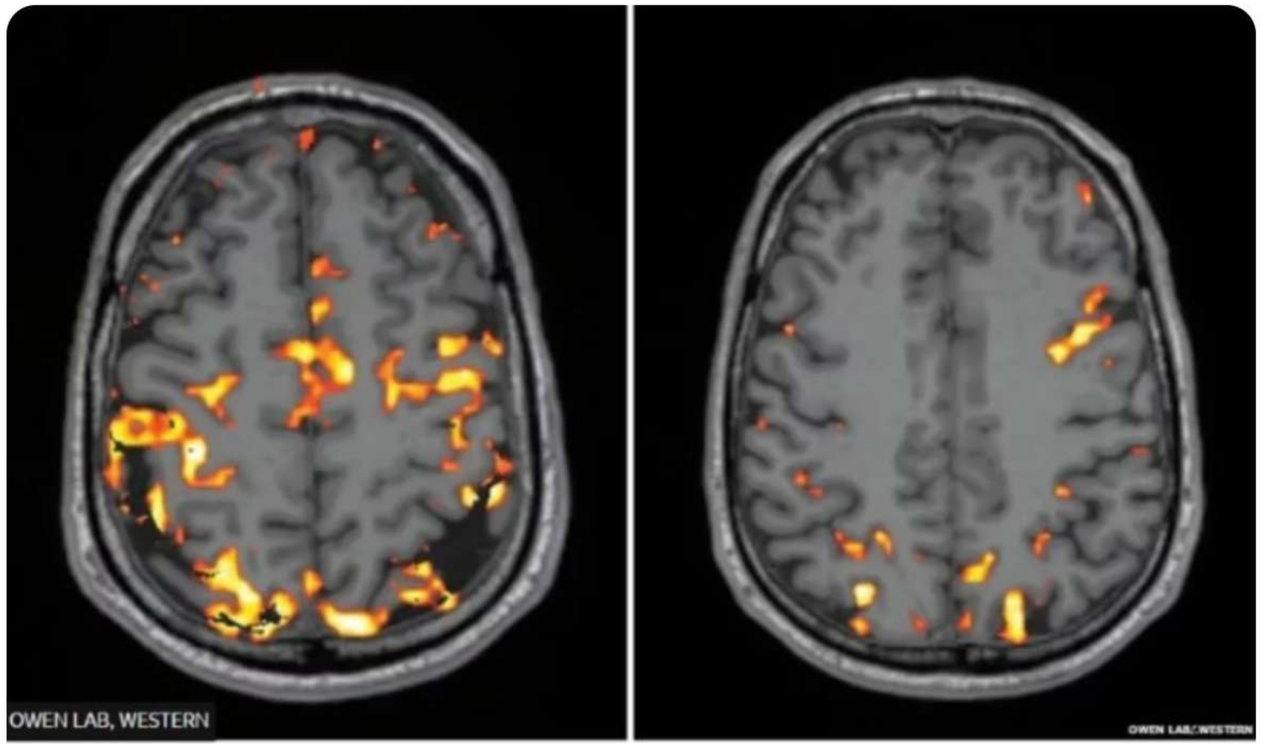
Why Should You Care?

- Brain scans showed significantly reduced activity after sleep deprivation

- Prof Owen: "Frontal and parietal lobes—key for decision-making, problem-solving, and memory—were much less active."

- Sleep deprivation slows reaction time and increases the risk of falling asleep at the wheel, making driving dangerous.



The scan on the left shows my brain activity during cognitive tests after a normal night's sleep, compared with my sleep-deprived brain, on the right

Source : https://www.bbc.com/news/health-40036667

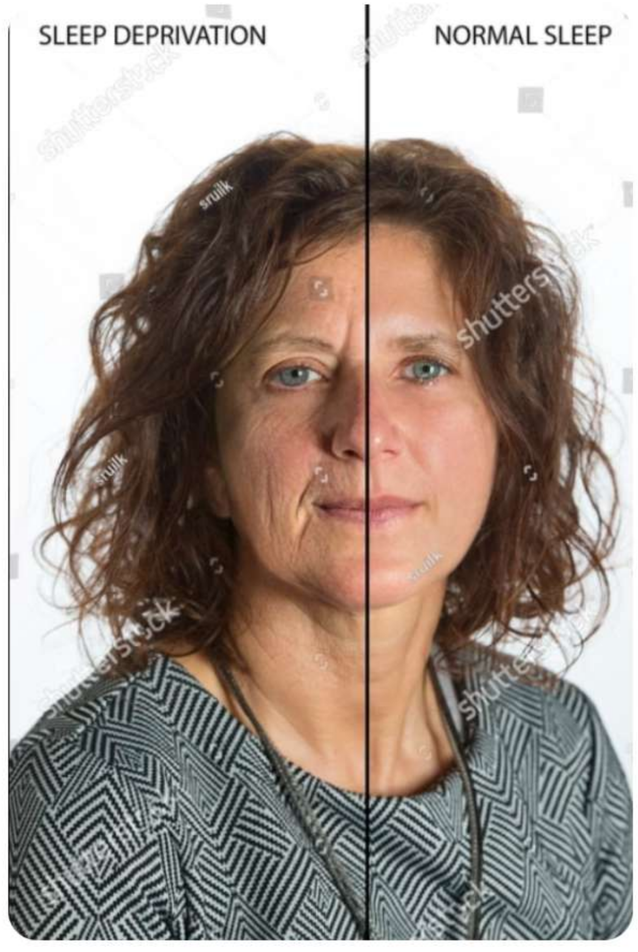
Why Sleep Needs Smarter Solutions?

- **Sleep Quality Varies**
  People feel tired after 4 hours of sleep and also often feel tired even after 8 hours of sleep, showing that duration alone doesn't guarantee rest.

- **Multiple Lifestyle Influences**
  Factors like stress, diet, exercise, and screen time affect sleep in complex ways.

- **Need for Personalization**
  Sleep needs and patterns differ from person to person, requiring customized understanding and solutions.

- **Health and Safety Risks**
  Poor sleep affects focus and reaction time, increasing risks like accidents and reduced productivity.



Objectives

Analyze Sleep Determinants

Investigate how lifestyle factors — physical activity, stress levels, and daily steps — interact with demographic variables to affect overall quality of sleep.

Develop Hybrid Prediction Model

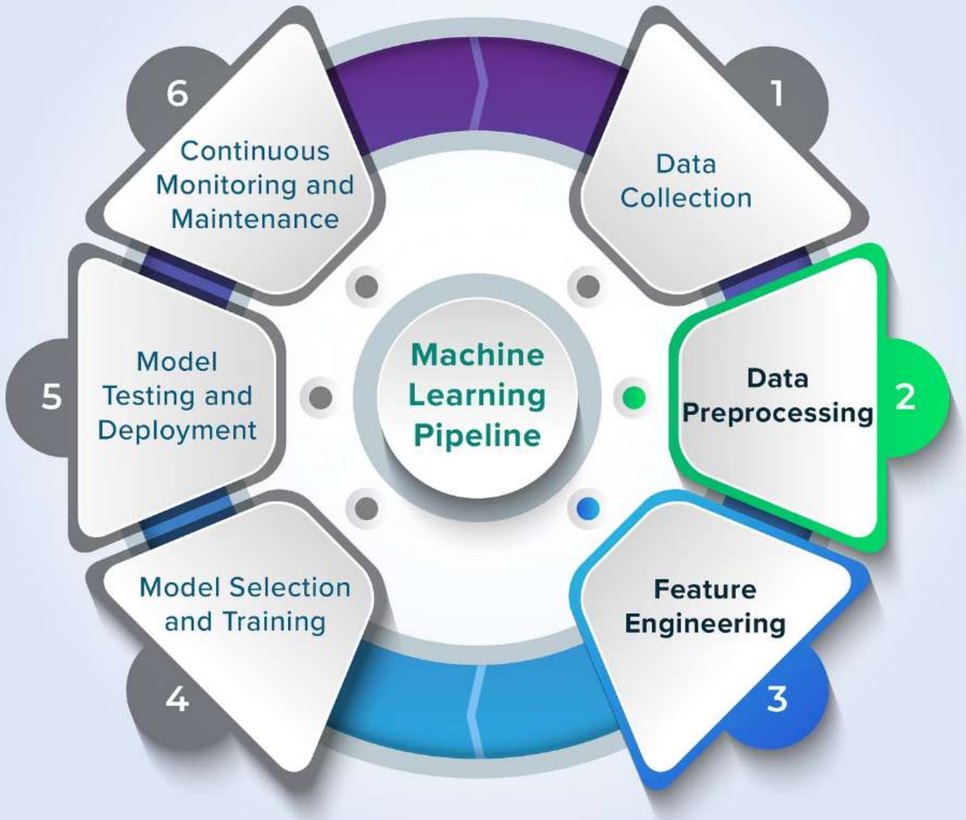
Build and compare advanced ML models (Decision Tree, Random Forest) enhanced with domain expertise to predict optimal sleep duration based on comprehensive health profiles.

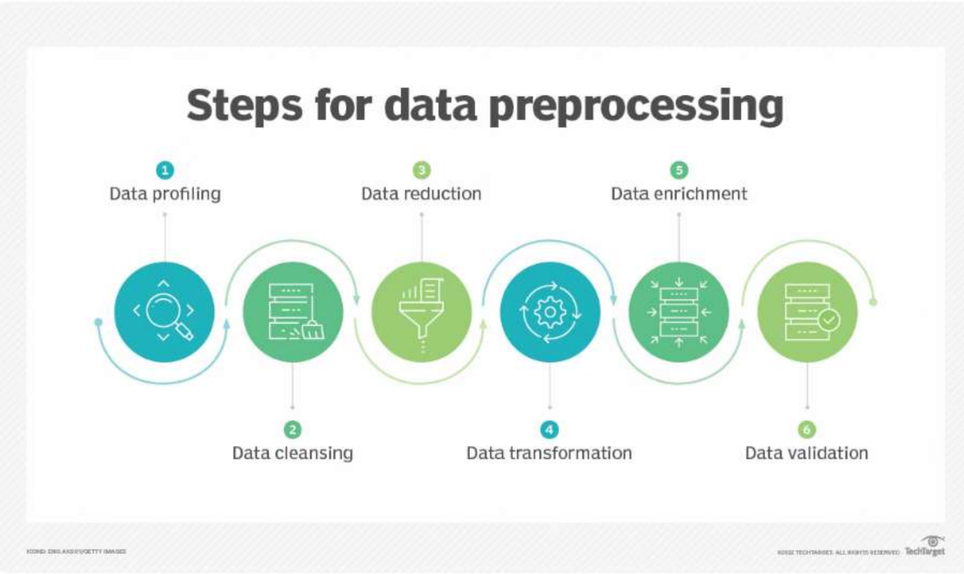
Create Personalized Recommendations

Generate tailored sleep duration guidelines that account for age, occupation, stress levels, and physiological metrics to improve individual sleep quality.

Interactive Visualization Dashboard

Design comprehensive visualization tools — sleep quality correlations, factor impact charts, and health metric assessments to facilitate data-driven sleep health decisions.





Methodology: Phase 1 – EDA & Preprocessing

1 Data Collection

Loaded sleep health dataset with demographic, physiological, and behavioral metrics.

2 Data Cleaning

Verified data integrity, standardized categories (Fixed BMI labels), and ensured consistent data types.

3 Feature Engineering

Created Age Groups, Blood Pressure Targets, and Heart Rate Targets classifications.

4 Exploratory Analysis

Visualized key health metrics distributions and explored relationships between sleep quality and factors like physical activity, stress levels, and BMI

Methodology: Phase 2 - Predictive Modeling

1 Model Selection

Implemented Decision Tree (primary) and Random Forest models Used PCA components and K-means clusters as features Decision Tree with max_leaf_nodes=25 performed best.

2 Training & Validation

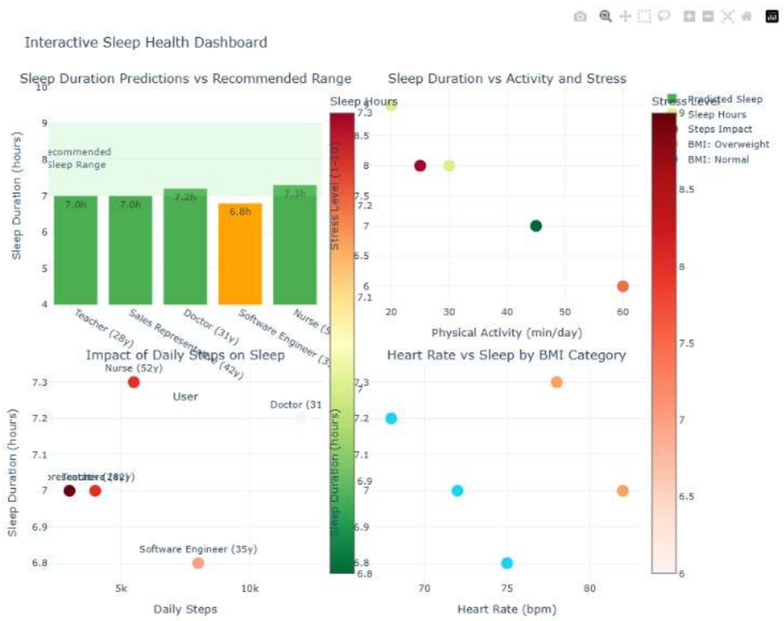
80/20 train/test split with 5-fold cross-validation Applied preprocessing pipeline for numerical/categorical features Handled missing values and encoding automatically

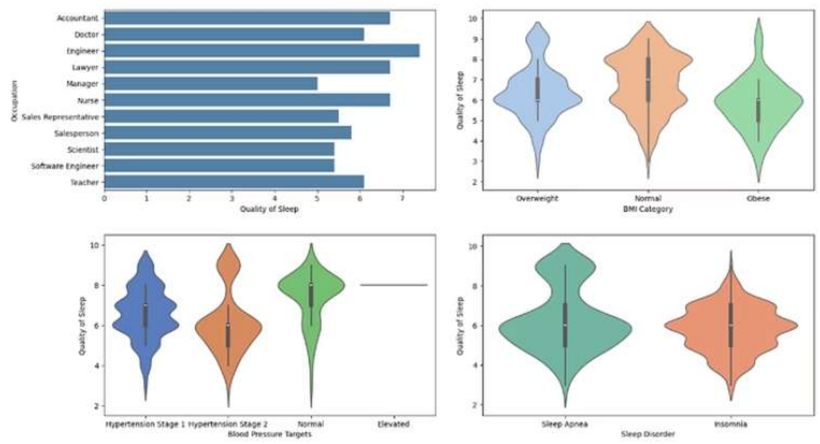
3 Hyperparameter Tuning

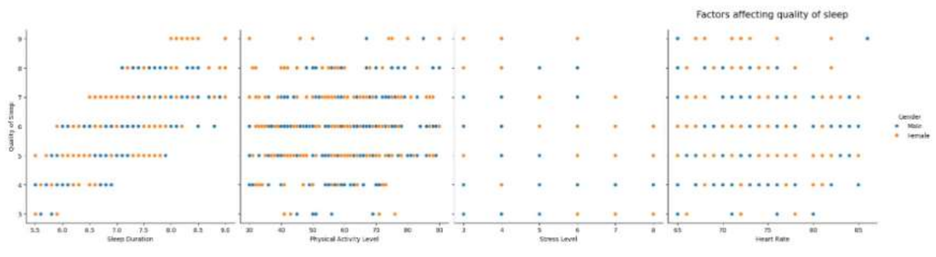
Tested Decision Tree with leaf nodes: 5-5000 Evaluated Random Forest with various configurations: Different estimators (50-200) Alternative criteria and depth settings Selected parameters based on lowest MAE

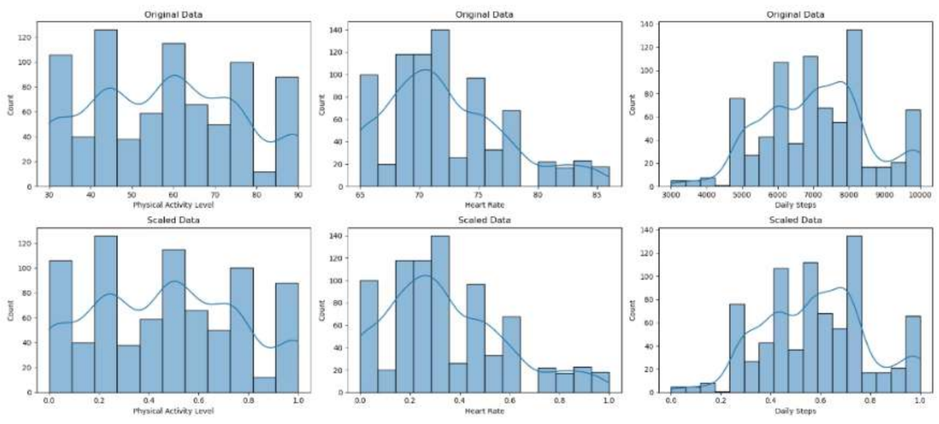
4 Evaluation Metrics

Primary metric: Mean Absolute Error (MAE) Results: Decision Tree ~0.5, Random Forest ~0.4 Final model balances complexity and prediction accuracy









Methodology: Phase 3 – Interpretability & Visualization

1

Global Feature Importance

Used mutual information scores to visualize how features like Physical Activity Level, Stress Level, and Sleep Duration impact sleep quality predictions.

2

Individual Case Studies

Created personalized analysis system that explains sleep predictions using domain knowledge adjustments and targeted recommendations based on user health metrics.

3

Dependence Plots

Explored relationships between factors through visualization: Sleep quality vs BMI Category and Stress Level Physical activity impact on sleep quality across demographics

4

Interactive Dashboards

Built interactive visualizations with Plotly: Sleep prediction comparisons against recommended ranges Health metrics assessment with radar charts Personalized PDF reports with tailored recommendations

Tech Stack

Programming

- Python for analysis and modeling
- Pandas and NumPy for data manipulation

Modeling & Visualization

- Decision Tree , Random Forest
- PCA , K- Means Clustering
- Matplotlib, Seaborn for charts

Deployment

- Streamlit and Dash for dashboards

Thank You