Information Science and Engineering
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BCS602 - Machine Learning

Project Title : Sleep Pattern Analyzer from Smartwatch Data

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SECTION AND SEM:B SECTION (VI SEMESTER)

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Problem Statement

Problem Statement : Sleep Pattern Analyzer from Smartwatch Data

To analyze and categorize individuals based on their sleep patterns using clustering algorithms, aiming to uncover meaningful insights from sleep-related parameters such as Sleep Duration, Sleep Efficiency, and Sleep Stages (Deep, REM, and Light Sleep), and to visualize these clusters for better interpretation and health analysis

Introduction

In today's fast-paced world, sleep issues have become increasingly common due to irregular routines, stress, and unhealthy lifestyle habits. Understanding our sleep quality is essential for maintaining good health, yet many people struggle to interpret the sleep data collected by their smartwatches.

To address this, we developed a Sleep Pattern Analyzer—a machine learning-powered web application that uses the K-Means Clustering algorithm to analyze smartwatch sleep data. This project automatically groups individuals based on key sleep metrics like Sleep Duration, Sleep Efficiency, Sleep Stages, and Heart Rate Variability, helping users understand their sleep behavior and identify potential issues.

The project not only visualizes these sleep clusters using graphs and charts, but also offers personalized insights and suggestions to improve sleep quality—making it a smart and accessible tool for better sleep health.

Objective

The main objective of this project is to analyze and classify sleep patterns using smartwatch data through the K-Means Clustering algorithm. By clustering individuals based on features like sleep duration, efficiency, and sleep stages, the system aims to:

- 📊 Identify distinct sleep pattern groups (e.g., restful, disturbed).
- 🧠 Provide meaningful visualizations for better understanding of sleep behavior.
- 💡 Offer personalized health insights and suggestions to improve sleep quality.
- 📱 Enable users to interactively explore their sleep data through a web interface.

This helps users and health-conscious individuals monitor their sleep trends and make informed lifestyle changes.

Literature Review

1	Sleep Monitoring Using Wearable Devices	This study analyzed sleep quality using data from wearable devices like smartwatches. It focused on metrics like sleep duration and efficiency.	Collected real-time data from smartwatches and applied statistical analysis.	Wearables can effectively collect sleep data and help detect sleep patterns in individuals.
2	Sleep Stage Detection Using Machine Learning	Focused on classifying sleep stages using supervised and unsupervised ML models, including K-Means.	Applied K-Means clustering and SVMs on sleep features like HRV, REM, and deep sleep %.	K-Means clustering proved effective in grouping sleep patterns based on physiological features.
3	Visualization Techniques in Health Data Analytics	Reviewed various visualization methods for health-related datasets, especially time-series sleep data.	Reviewed various visualization methods for health-related datasets, especially time-series sleep data.	Reviewed various visualization methods for health-related datasets, especially time-series sleep data.

Methodology of Proposed System

Data Handling & Preprocessing

1. Data Collection

Sleep data is collected from smartwatches.

Each record includes:

- Sleep Duration (hours)
- Time to Fall Asleep (mins)
- Night Wakings
- Sleep Efficiency (%)
- Heart Rate Variability
- Deep, REM, Light Sleep %

2. Data Preprocessing

Cleaning: Remove missing/null values.

Normalization: Scale values using MinMaxScaler (0 to 1) to avoid feature dominance.

Feature Selection: Use only key features for clustering:

sleepDuration, sleepEfficiency, deepSleepPercentage, remSleepPercentage, lightSleepPercentage, etc

Clustering & Visualization

3. Clustering with K-Means Algorithm

Choose optimal K using Elbow Method.

Apply K-Means to group users into sleep pattern clusters.

Each cluster represents a distinct sleep behavior group.

4. Visualization

Scatter Plot: Sleep Duration vs Efficiency colored by clusters.

Cluster Centroids: Average feature values shown visually.

Pie Charts: Sleep stage % per cluster (Light, REM, Deep).

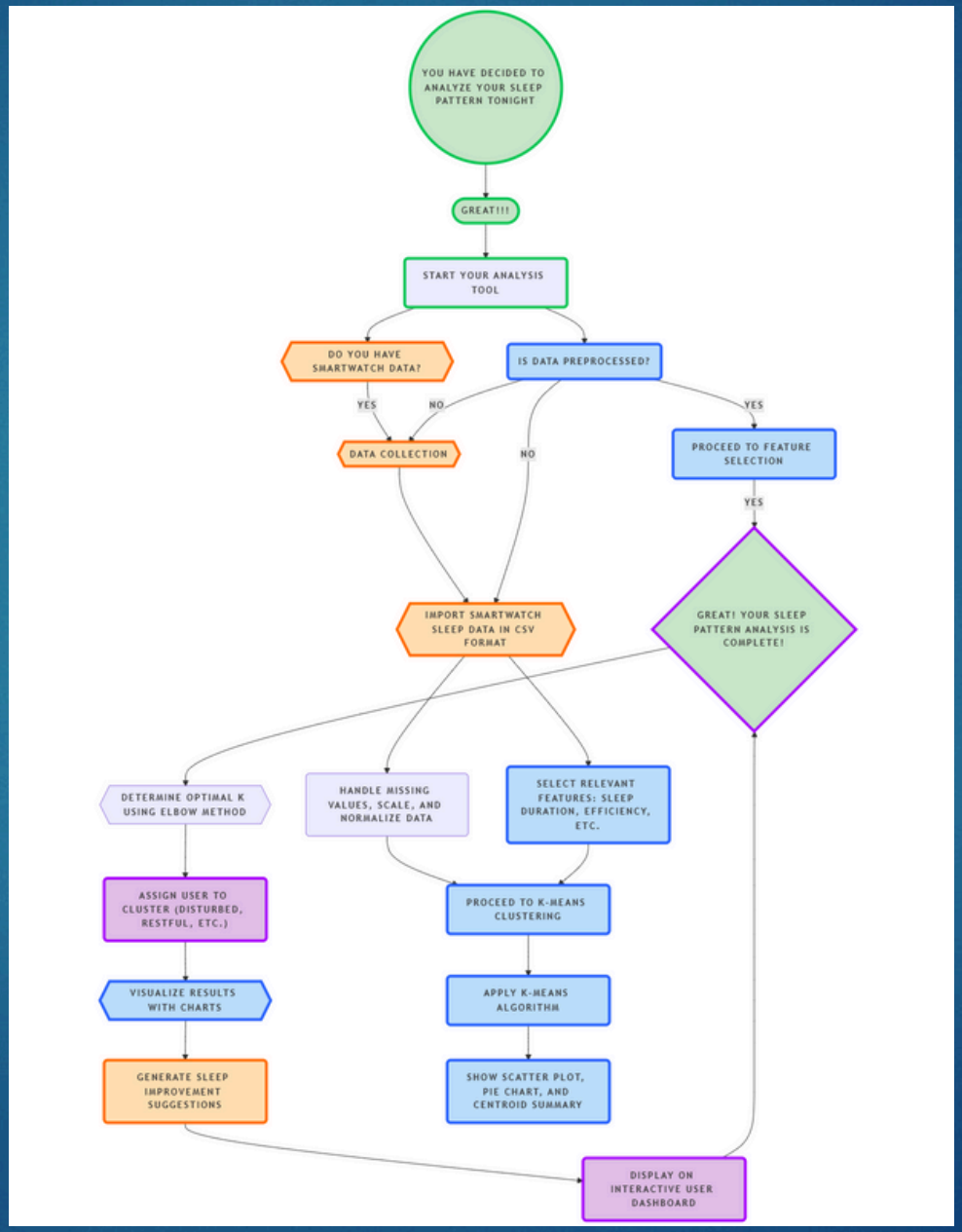
5. Insights & Recommendations

Based on cluster, provide tips:

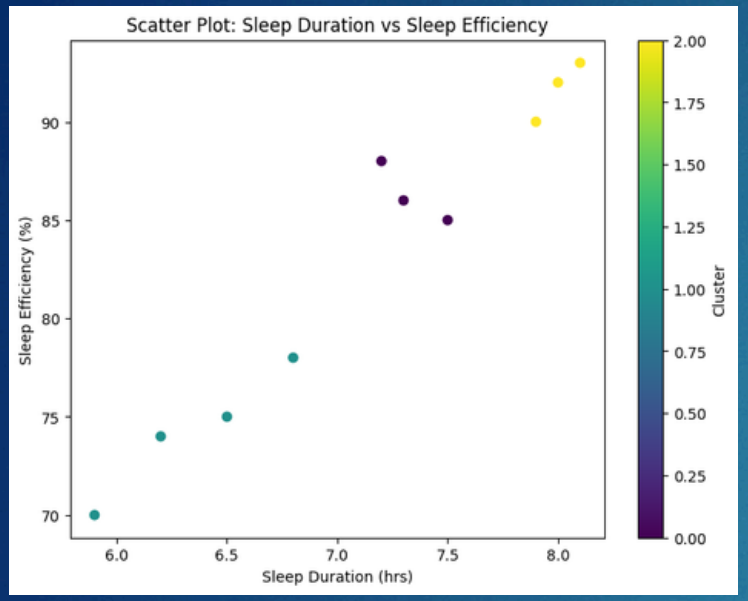
Improve routine, reduce screen time, hydration, etc.

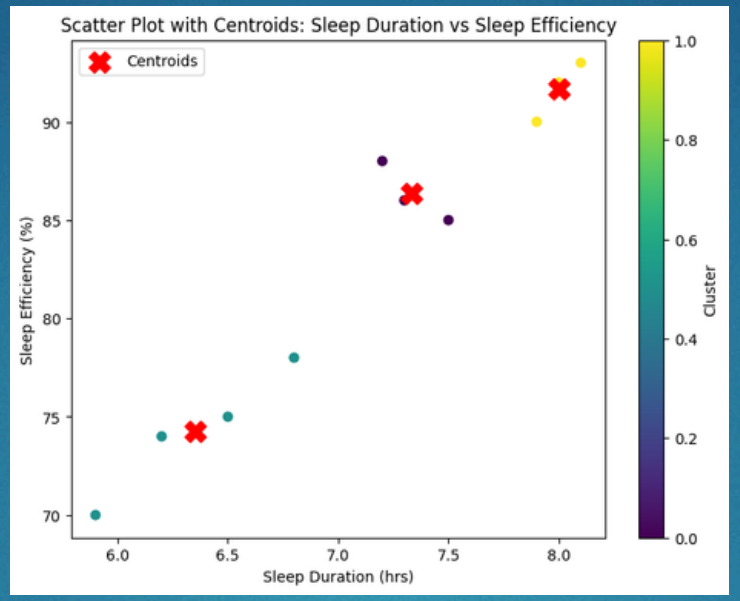
Users see which cluster they belong to and get personalized sleep advice.

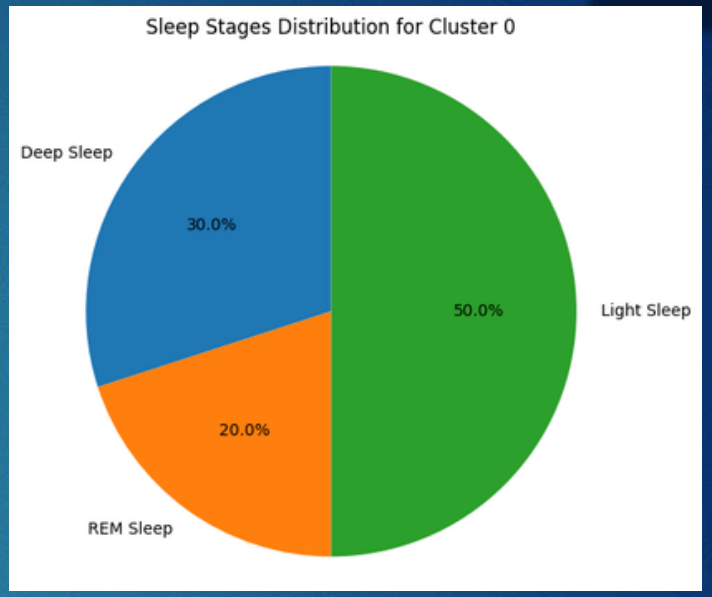
System Work Flow Diagram

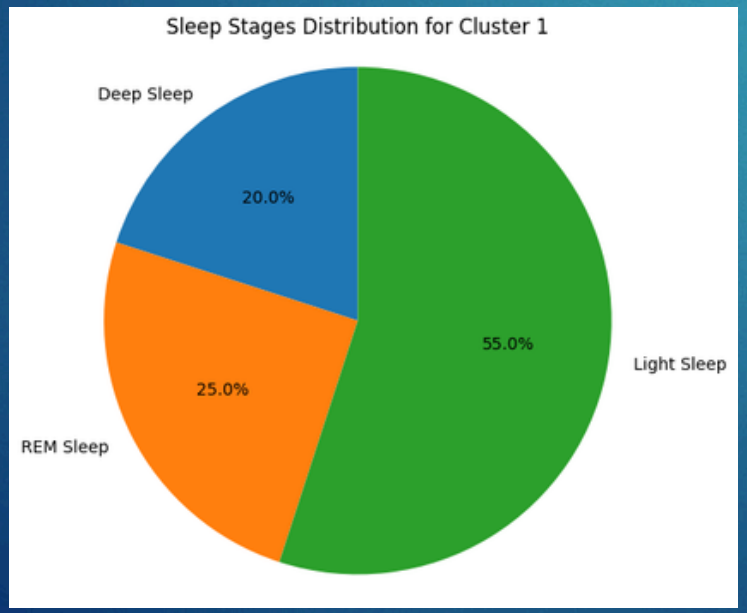


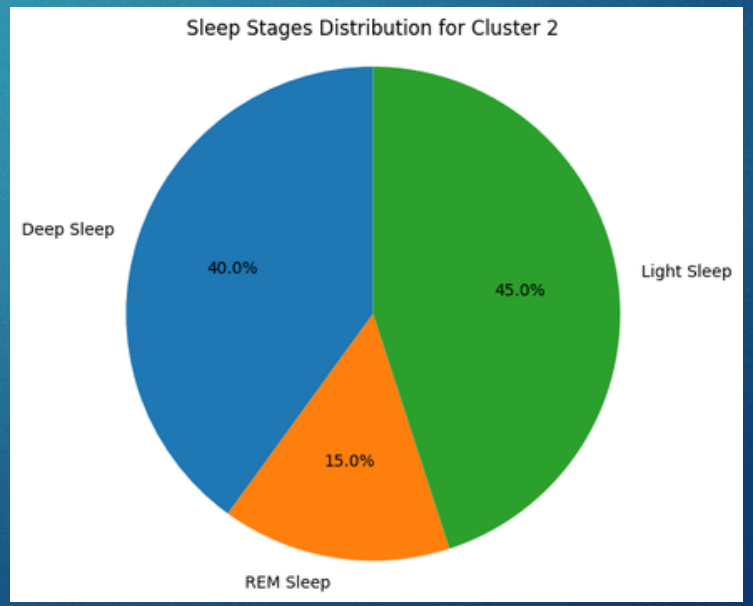
Results


Scatter Plot: Sleep Duration vs Sleep Efficiency
Sleep Efficiency (%)
Sleep Duration (hrs)
Cluster


Scatter Plot with Centroids: Sleep Duration vs Sleep Efficiency
Centroids
Sleep Efficiency (%)
Sleep Duration (hrs)
Cluster


Sleep Stages Distribution for Cluster 0
Deep Sleep
30.0%
50.0%
Light Sleep
20.0%
REM Sleep


Sleep Stages Distribution for Cluster 1
Deep Sleep
20.0%
55.0%
Light Sleep
25.0%
REM Sleep


Sleep Stages Distribution for Cluster 2
Deep Sleep
40.0%
45.0%
Light Sleep
15.0%
REM Sleep

Conclusion

This project successfully demonstrates how machine learning, specifically the K-Means Clustering algorithm, can be applied to smartwatch sleep data to uncover meaningful insights about an individual's sleep patterns. By analyzing key features such as sleep duration, sleep efficiency, and sleep stage distribution, users can be grouped into clusters representing different sleep behavior profiles — like Restful Sleepers, Light Sleepers, or Disturbed Sleepers.

The integration of data preprocessing, clustering, and visualization techniques not only enables accurate pattern detection but also makes the insights understandable through user-friendly graphs and charts. Additionally, the system provides personalized recommendations based on the cluster a user falls into, thereby helping improve their overall sleep hygiene.
This analyzer serves as a useful tool in promoting health awareness, empowering users to make informed decisions about their sleep habits with the help of technology.

References

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- Live Demo of the Completed Project

- LINK TO PROJECT