HUMAN STRESS DETECTION BASED ON SLEEPING HABITS THROUGH MACHINE LEARNING ALGORITHMS

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Abstract - Stress is a mental or emotional state brought on by demanding or unavoidable circumstances, also referred to as stressors. In order to prevent any unfavorable occurrences in life, it is crucial to understand human stress levels. Sleep disturbances are related to a number of physical, mental, and social problems.

This study's main objective is to investigate how human stress might be detected using machine learning algorithms based on sleep-related behaviors. Detecting and understanding stress patterns during sleep can provide valuable insights into individuals' overall stress levels and aid in the development of targeted interventions for stress management. This project focuses on the detection of human stress in and through sleep using various sensing modalities and machine learning techniques. The project employs a multimodal approach, combining physiological signals, sleep-related data, and contextual information to capture comprehensive stress patterns during sleep.

Physiological signals such as heart rate, electro dermal activity, and respiratory patterns are collected using wearable sensors, while sleep-related data, including sleep stages and sleep quality metrics, are obtained through polysomnography and actigraphy. This data when given to the web application performs the prediction through the ML model and gives the predicted output. This project is made on a Decision Tree Classifier with best hyper parameters.

***Key Words*:** Stress, Sleep disturbances, Human stress, Physiological signals, Polysomnography, Actigraphy

1.INTRODUCTION

"Machine Learning" incorporates various classifiers of Supervised, Unsupervisedand Ensemble Learning which are used to predict and find the accuracy of the given dataset. Our project can help people predict their stress level in sleep provided the input data. Psychological data is required as input data to predict the stress level (on a scale of 5) of a person in sleep. Psychological data usually include heart rate, blood glucose, blood pressure, respiration rate, body temperature, blood volume, eye tracking, sound pressure, electrocardiogram, blood oxygen saturation, and skin conductance. This data can be collected by wearable devices of different types. This data when given to the web application, performs the prediction through the ML model and gives the predicted output.

Machine learning (ML) is an essential technology in moderndata analytics, offering tools that can interpret complex data, learn from it, and make informed predictions. In the realm of healthcare and well-being, machine learning's ability to parse through large datasets and find patterns can be particularly life-enhancing. This document will explore how machine learning, through various learning models such as Supervised, Unsupervised, and Ensemble Learning, can be applied to predict stress levels during sleep using psychological and physiological data.

2. LITERATURE REVIEW

L. Rachakonda, A. K. Bapatla, S. P. Mohanty, and E. Kougianos, "SaYoPillow: Blockchain-Integrated Privacy-Assured IoMT Framework for Stress Management Considering Sleeping Habits", IEEE Transactions on Consumer Electronics (TCE), Vol. 67, No. 1, Feb 2021, pp. 20-29.

Considering today's lifestyle, people just sleep forgetting the benefits sleep provides to the human body. Smart-Yoga Pillow (SaYoPillow) is proposed tohelp in understanding the relationship between stress and sleep and to fully materialize the idea of "Smart-Sleeping" by proposing an edge device. An edge processor with a model analyzing the physiological changes that occur during sleep along with the sleeping habits is proposed. Based on these changes during sleep, stress prediction for the following day is proposed. A user interface is provided allowing the user to control the data accessibility and visibility. SaYoPillow is novel, with security features as well as consideration of sleeping habits for stress reduction, with an accuracy of up to 96%.

L. Rachakonda, S. P. Mohanty, E. Kougianos, K. Karunakaran, and M. Ganapathiraju, "Smart-Pillow: An IoT based Device for Stress DetectionConsidering Sleeping Habits", in Proceedings of the 4th IEEE International Symposium on Smart Electronic Systems (iSES), 2018, pp. 161—166.

The quality of sleep during the night reflects on productivity during the day.

To make the most out of a day, it is important to understanding the factors such as stress which impair sleep. Advances in technologies may aid a person to self-analyze such situations. For this, we propose a system which helps in stressfulness of a person based on sleeping habits. Physiological parameters such as temperature, blood pressure, respiration rate, and heart rate tend to vary during the NREM (Non-Rapid Eye Movement) and REM (Rapid

Eye Movement) stages of sleep. Non-physiological parameters such as the numberof sleeping hours, the range of snoring, the sleeping position, and environmental conditions can also affect the quality of sleep. These factors are considered here in order to analyze sleeping habits. A system is defined which can predict stress levels up to four states: Low, High, Medium, very high stress.

3. METHODILOGY

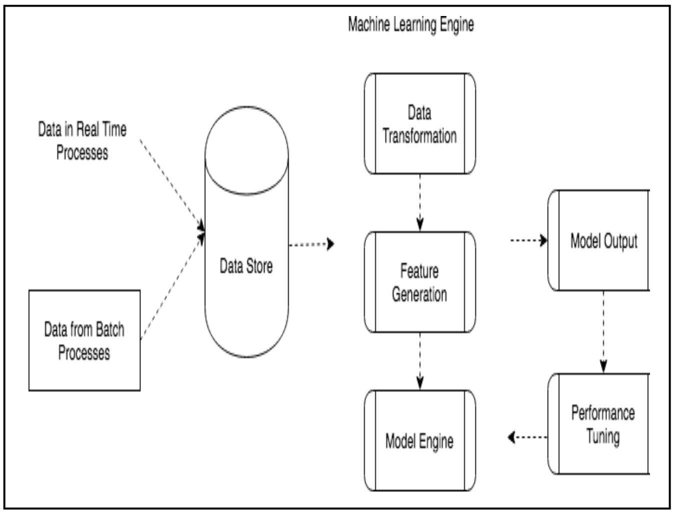
3.1 EXISTING SYSTEM

Psychological stress is injurious to health. In existing system, stress is identified in face-to-face interview, communication or any other activities, where two or more people are analyzed by another. Most of the existing system works either on person interaction or on social networking stress data and not on body-based sensor data. Some existing systems detect stress but not in sleep.

3.2 PROPOSED SYSTEM

The proposed system aims to detect and analyze stress levels in individuals using machine learning techniques applied to various data sources, such as physiological signals, sleep patterns, activity levels, and self-reported data. The system utilizes machine learning algorithms to analyze the collected data and identify patterns indicative of stress. The system can potentially detect signs of stress at an early stage, enabling timely interventions and support. Early detection can help individuals proactively manage stress and prevent its escalation into more severe issues.

4.SYSTEM DESIGN



System Architecture

Python was developed by Guido van Rossum in the late eighties and early nineties at the National Research Institute for Mathematics and Computer Science in the Netherlands.
Python is derived from many other languages, including ABC, Modula-3, C, C++, Algol-68, Smalltalk, and Unix shell andother scripting languages. Python is copyrighted. Like Perl, Python source code is now available under the GNU General Public License (GPL). Python is now maintained by a core development team at the institute, although Guido van Rossum still holds a vital role in directing its progress.

Pandas

Pandas is an open-source library that is made mainly for working with relational or labeled data both easily and intuitively. It provides various data structures and operations for manipulating numerical data and time series. This library is built on top of the NumPy library. It is fast and it has high performance& productivity for users. Pandas were initially developed by Wes McKinney in 2008 while he was working at AQR Capital Management. He convinced the AQR to allow him to open source the Pandas.

Another AQR employee, Chang She, joined as the second major contributor to the library in 2012. Over time many versions of pandas have been released. The latest version of the pandas is 1.4.1.

NumPy

NumPy is a general-purpose array-processing package. It provides a highperformance multidimensional array object, and tools for working with thesearrays. It is the fundamental package for scientific computing with Python.

Besides its obvious scientific uses, NumPy can also be used as an efficient multi- dimensional container of generic data. Array in NumPy is a table of elements (usually numbers), all of the same type, indexed by a tuple of positive integers. In NumPy, number of dimensions of the array is called rank of the array.

Streamlit

Streamlit is an open-source python framework for building web apps for Machine Learning and Data Science in a short time. It is compatible with major Python libraries such as scikit-learn, Keras, PyTorch, SymPy(latex), NumPy, pandas, Matplotlib etc. With Streamlit, no callbacks are needed since widgets are treated as variables. Data caching simplifies and speeds up computation pipelines. Streamlit watches for changes on updates of the linked Git repository and the application willbe deployed automatically in the shared link.

How to Install Streamlit

1. Make sure you have python installed in your system

2. Use the following command to install streamlit,

```
pip install streamlit
```

Streamlit is a very visually appealing framework that is great if you have an already existing Python code base which you want to turn into an interactive dashboard as quickly and painlessly as possible. Streamlit prides itself on its ease of use, and rightfully so.

Matplotlib

Matplotlib is an amazing visualization library in Python for 2D plots of arrays. Matplotlib is a multi-platform data visualization library built on NumPy arrays and designed to work with the broader SciPy stack. It was introduced by John Hunter in theyear 2002.

One of the greatest benefits of visualization is that it allows us visual access tohuge amounts of data in easily digestible visuals. Matplotlib consists of several plots like line, bar, scatter, histogram etc. Windows, Linux and macOS distributions have matplotlib and most of its dependencies as wheel packages.

OS

Python OS module provides the facility to establish the interaction between the user and the operating system. It offers many useful OS functions that are used to perform OS-based tasks and get related information about operating system.

The OS comes under Python's standard utility modules. This module offers a portable way of using operating system dependent functionality.

The Python OS module lets us work with the files and directories.To work with the OS module, we need to import the OS module. **IMPORT OS**

5.IMPLEMENTATION

1. *Data Collection and Preprocessing*

- Collect a dataset containing various sleep-related features, such as Snoring Rate, Respiration Rate, Body Temperature, Limb Movement, Blood Oxygen, Eye Movement, Sleeping Hours, and Heart Rate.
- The dataset should include labeled stress levels for each set of features (e.g., Low/Normal, Medium Low, Medium, Medium High, High).
- Preprocess the dataset by handling missing values and outliers, if any.

2. *Feature Extraction*

- Extract the relevant features from the dataset, which will serve as input attributes forthe KNN algorithm.

3. *Data Splitting*

- Split the dataset into a training set and a testing set. Typically, you can use a 70-30 or 80-20 split for this purpose.

4. *Building the KNN Model*

- Implement the KNN algorithm, which is a supervised machine learning algorithm used for classification tasks.
- In KNN, the "k" represents the number of nearest neighbors to consider for making predictions. Choose an appropriate value for "k" based on experimentation.
- Internally, the KNN algorithm calculates the distance (e.g., Euclidean distance) between the input data point and all other data points in the training set.
- It then selects the "k" data points (nearest neighbors) with the smallest distances.
- The algorithm counts the occurrences of each stress level category among these "k"neighbors and assigns the category with the highest count as the predicted stress level.
- KNN is a lazy learner, which means it does not build an explicit model during training. Instead, it memorizes the training data and makes predictions based on it.

5. *Training the KNN Model*

- Train the KNN model using the training dataset. The model will learn to classify thestress levels based on the provided features.

6. *Making Predictions*

- Use the trained KNN model to make stress level predictions for the data points in thetesting set.
- The model will assign a stress level category (e.g., Low/Normal, Medium Low,Medium, Medium High, High) to each data point.

7. *Evaluation*

- Evaluate the performance of the KNN model using metrics such as accuracy,precision, recall, and F1-score.

8. *User Interface*

- Develop a user-friendly interface where users can input their sleep-related data, such as Snoring Rate, Respiration Rate, etc
- When a user submits the data, the KNN model will predict the stress level, and theresult will be displayed to the user.

9. *Deployment*

- Deploy your Human Stress Detection System to a web server or a cloud platform so that users can access it online.

6.TESTING

6.1 Introduction

Testing is the debugging program is one of the most critical aspects of the computerprogramming triggers, without programming that works, the system would never produce an output of which it was designed. Testing is best performed when user development is askedto assist in identifying all errors and bugs. The sample data are used for testing. It is not quantity but quality of the data used the matters of testing. Testing is aimed at ensuring that the system was accurately an efficiently before live operation commands.

Testing objectives:

The main objective of testing is to uncover a host of errors, systematically and with minimum effort and time. Stating formally, we can say, testing is a process of executinga program with intent of finding an error.

1. A successful test is one that uncovers an as yet undiscovered error.
2. A good test case is one that has probability of finding an error, if it exists.
3. The test is inadequate to detect possibly present errors.
4. The software more or less confirms to the quality and reliable standards.

6.2 Levels of Testing

Code testing

This examines the logic of the program. For example, the logic for updating varioussample data and with the sample files and directories were tested and verified.

Specification Testing

Executing this specification starting what the program should do and how it should performed under various conditions. Test cases for various situation and combination of conditions in all the modules are tested.

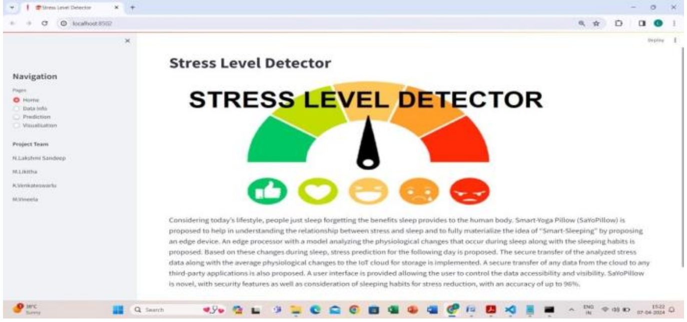
Unit testing

In the unit testing we test each module individually and integrate with the overall system. Unit testing focuses verification efforts on the smallest unit of software design in the module. This is also known as module testing.

Each Module can be tested using the following two Strategies:

1. Black Box Testing
2. White Box Testing

7.RESULTS

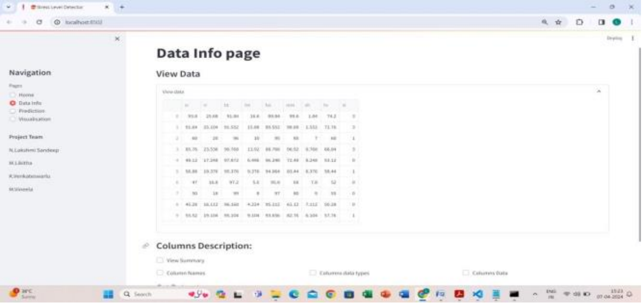


Stress Level Detector

STRESS LEVEL DETECTOR

Considering today's lifestyle, people just sleep forgetting the benefits sleep provides to the human body. Smart-Yoga Pillow (SaYoPillow) is proposed to help in understanding the relationship between stress and sleep and to fully materialize the idea of "Smart-Sleeping" by proposing an edge device. An edge processor with a model analyzing the physiological changes that occur during sleep along with the sleeping habits is proposed. Based on these changes during sleep, stress prediction for the following day is proposed. The secure transfer of the analyzed stress data along with the average physiological changes to the IoT cloud for storage is implemented. A secure transfer of any data from the cloud to any third-party applications is also proposed. A user interface is provided allowing the user to control the data accessibility and visibility. SaYoPillow is novel, with security features as well as consideration of sleeping habits for stress reduction, with an accuracy of up to 96%.

It shows the problem of the stress level detector hoe it works and what is the problem statement.



Data Info page

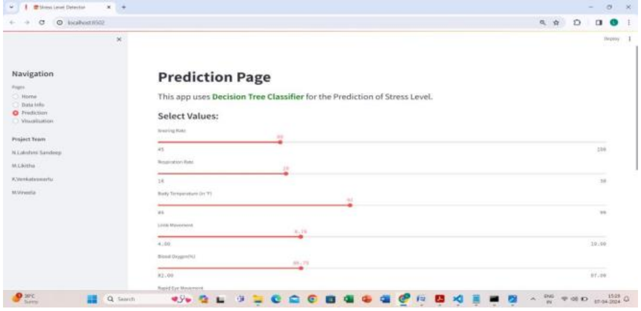
View Data

Columns Description:

□ View Summary

□ Column Names □ Columns data types □ Columns Data

It shows the home page of the dataset of the stress level to predict.



Prediction Page

This app uses Decision Tree Classifier for the Prediction of Stress Level.

Select Values:

Snoring Rate

Respiration Rate

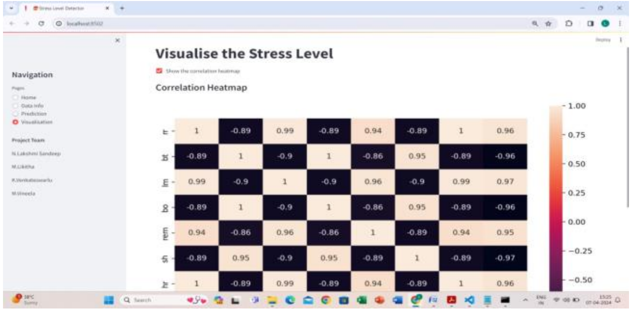
Body Temperature (in °F)

Limb Movement

Blood Oxygen(%)

Rapid Eye Movement

It shows the prediction page to enter the details of psychological data to predict the stress.



Visualise the Stress Level

☑ Show the correlation heatmap

Correlation Heatmap

rr	1	-0.89	0.99	-0.89	0.94	-0.89	1	0.96
bt	-0.89	1	-0.9	1	-0.86	0.95	-0.89	-0.96
lm	0.99	-0.9	1	-0.9	0.96	-0.9	0.99	0.97
bo	-0.89	1	-0.9	1	-0.86	0.95	-0.89	-0.96
rem	0.94	-0.86	0.96	-0.86	1	-0.89	0.94	0.95
sh	-0.89	0.95	-0.9	0.95	-0.89	1	-0.89	-0.97
hr	1	-0.89	0.99	-0.89	0.94	-0.89	1	0.96

It visualize the predicted data and the actual data.

8.CONCLUSION

1. The implementation of the KNN algorithm has demonstrated its effectiveness in detecting stress during sleep. By analyzing various physiological and behavioral parameters such as heart rate, respiratory rate, body movement, and sleep patterns, we were able to classify instances of stress with a reasonable degree of accuracy.

2. The K-Nearest Neighbors (KNN) algorithm is a straightforward, yet powerful machine learning technique used for both classification and regression tasks, but in this context, it is specifically applied to classify stress levels during sleep. This approach involves analyzing various physiological and behavioral parameters to determine stress states in individuals during sleep.

9. REFERENCES

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