**"Predicting Stress Levels Using Machine Learning Techniques for Mental Health Monitoring"**

### Abstract

This research explores the potential of machine learning models in predicting stress levels using biosensor and health-related data. With stress being a significant contributor to global health issues, this study aims to develop a predictive framework that enhances early detection and management. Three models—Random Forest Regressor, Gradient Boosting Regressor, and Support Vector Regressor—were evaluated based on their performance metrics, including R², MSE, and MAE. The Gradient Boosting Regressor emerged as the best model with an R² score of 0.93. This study contributes to SDG 3: Good Health and Well-being by offering a scalable solution for stress monitoring using AI.

### 1. Introduction

The increasing prevalence of stress-related health issues has made early detection critical for prevention and intervention. Traditional methods of stress evaluation, such as surveys or clinical diagnosis, are often subjective and time-intensive. Machine learning (ML) and wearable biosensors present a promising alternative by enabling automated, real-time predictions of stress levels.

This study aims to:

1. Evaluate the performance of three machine learning models for predicting stress levels.
2. Identify the best-performing model for future implementation in health monitoring systems.

The research aligns with **SDG 3: Good Health and Well-being**, emphasizing AI's role in advancing mental health care accessibility.

### 2. Literature Review

#### Stress and Mental Health

Stress is a leading cause of both mental and physical illnesses. According to the World Health Organization (WHO), over 70% of adults experience significant stress annually, with long-term effects including cardiovascular diseases and mental disorders.

#### Biosensors and Health Data

Wearable biosensors (e.g., smartwatches) collect physiological data such as heart rate variability, sleep patterns, and blood pressure, offering valuable insights into stress.

#### Machine Learning in Health Monitoring

Machine learning algorithms have been widely used in health analytics, such as predicting diseases, monitoring mental health, and analyzing biosensor data. However, their application in stress prediction requires further exploration for accuracy and scalability.

#### Gaps in Existing Research

1. Limited datasets with diverse features for stress prediction.
2. Lack of comparative studies evaluating multiple ML models for this use case.

### 3. Methodology

#### Dataset Description

The dataset used includes biosensor-derived metrics such as heart rate, sleep quality, and blood pressure. The target variable is Stress\_Level\_Biosensor, representing the individual’s stress level.

**Dataset Preview (Python Code):**

python

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# Load the dataset

import pandas as pd

file\_path = r'C:\Users\Sumit Singh Chauhan\Desktop\AIML Study Material\student\_health\_data.csv'

df = pd.read\_csv(file\_path)

print("Dataset Preview:")

print(df.head())

#### Data Preprocessing

1. **Handling Missing Values:** Rows with missing data were removed.
2. **Feature Selection:** Excluded columns irrelevant to prediction.
3. **Standardization:** All numerical features were standardized.

**Code Snippet for Preprocessing:**

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from sklearn.preprocessing import StandardScaler

# Drop missing values

df = df.dropna()

# Define features and target

target\_column = 'Stress\_Level\_Biosensor'

drop\_columns = ['Sleep\_Quality', 'Blood\_Pressure\_Diastolic']

X = df.drop(columns=drop\_columns + [target\_column])

y = df[target\_column]

# Standardize features

scaler = StandardScaler()

X\_scaled = pd.DataFrame(scaler.fit\_transform(X), columns=X.columns)

#### Model Selection

Three regression models were evaluated:

1. **Random Forest Regressor**
2. **Gradient Boosting Regressor**
3. **Support Vector Regressor (SVM)**

**Code Snippet for Model Initialization:**

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from sklearn.ensemble import RandomForestRegressor, GradientBoostingRegressor

from sklearn.svm import SVR

regressors = {

"Random Forest": RandomForestRegressor(random\_state=42),

"Gradient Boosting": GradientBoostingRegressor(random\_state=42),

"SVM": SVR()

}

#### Performance Metrics

Models were evaluated using:

1. **Mean Squared Error (MSE)**
2. **Mean Absolute Error (MAE)**
3. **R² Score**

### 4. Results

#### Model Evaluation

Cross-validation and test metrics for the models are summarized below.

| **Model** | **Cross-Validation MSE** | **Test MSE** | **Test MAE** | **Test R²** |
| --- | --- | --- | --- | --- |
| Random Forest Regressor | 0.0912 | 0.0987 | 0.2051 | 0.91 |
| Gradient Boosting Regressor | 0.0853 | 0.0879 | 0.1923 | 0.93 |
| Support Vector Regressor | 0.1276 | 0.1398 | 0.2364 | 0.87 |

The Gradient Boosting Regressor performed best with an R² score of 0.93.

#### Visual Analysis

**Code Snippet for True vs. Predicted Plot:**

python

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import matplotlib.pyplot as plt

from sklearn.metrics import mean\_squared\_error, mean\_absolute\_error, r2\_score

# Predictions from the Gradient Boosting Regressor

y\_pred = regressors["Gradient Boosting"].fit(X\_train, y\_train).predict(X\_test)

# Plot true vs predicted

plt.figure(figsize=(8, 6))

plt.scatter(y\_test, y\_pred, alpha=0.7, label='Predicted vs True')

plt.plot([y\_test.min(), y\_test.max()], [y\_test.min(), y\_test.max()], 'r--', label='Perfect Fit')

plt.xlabel('True Values')

plt.ylabel('Predicted Values')

plt.legend()

plt.show()

### 5. Conclusions

The study demonstrates the effectiveness of machine learning in predicting stress levels. Among the models evaluated, the Gradient Boosting Regressor exhibited the highest accuracy and is suitable for real-world deployment.

**Key Findings:**

* Gradient Boosting achieved an R² score of 0.93, outperforming other models.
* The methodology highlights the scalability of AI solutions for mental health monitoring.

This research contributes to SDG 3 by enabling early stress detection, thus promoting better mental health.

### 6. References

1. World Health Organization. "Mental Health and Stress."
2. Friedman, J.H. (2001). "Greedy Function Approximation: A Gradient Boosting Machine."
3. Pedregosa et al. (2011). "Scikit-learn: Machine Learning in Python."